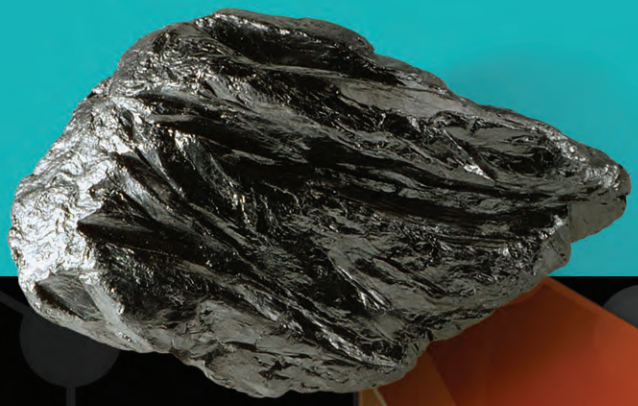
SANDIA NATIONAL LABORATORIES

UNIVERSITY PARTNERSHIPS

ANNUAL REPORT 2009



Portals into the breadth of Sandia science

Sandia National Laboratories

SAND 2010-3766P

ON THE COVER:

The front cover images of this brochure include a generic image of graphite (upper left), Laura Biedermann's scanning tunneling micrographs (STM) of multilayered, then single-layered graphene (two central orange-brown images), then finally, a molecular model of the planar hexagonal array of bonded carbon atoms in graphene (lower right); this hexagonal structure can be seen upon close inspection of the STM image adjacent to the model. This progressively more sophisticated insight into structure parallels the theme of this brochure and Dr. Biedermann's experience of discovering the depth and breadth of Sandia science (see page 17), which significantly changed her opinion about the prospects of working at a national laboratory such as Sandia.

ABSTRACT

The University Partnerships Office provides the leadership and framework for execution of the Laboratories' university partnerships strategy, as well as leadership within the Nuclear Weapons Complex regarding the role of university partnerships in supporting Complex Transformation. This office executes the strategy primarily through management of the Campus Executive Program, the umbrella under which corporate investments in research, recruiting and education are aligned with the Campus Executive universities. The University Partnerships Office serves as the point of contact for all university research issues and creates and implements those processes and tools that enable the partnerships. Investments are made in students and faculty via contract research and graduate research projects.

This FY 2009 University Partnerships Annual Report features examples of several different types of collaborations between Sandia and university partners. These include the Campus Executive Program, graduate research projects to talented pre-doctoral students, collaborations with recipients of the Presidential Early Career Award for Scientists and Engineers (PECASE) and a strategic partnership with the University of Texas System. We also report on the outcomes of the final year of research collaborations with early-career faculty in New Mexico universities through the just-ended Sandia University Research Program (SURP). The report is neither all-encompassing of the possibilities for Sandia-university collaborations, nor does it include all partnerships managed through the University Partnerships Program Office. Instead, it examines recent partnerships that provide a window into the types of collaborations that have been pursued or that are being developed in an ongoing fashion. In featuring 3 of 21 possible universities with which Sandia has a Campus Executive–type relationship (see page 5), the intent is to disclose and exemplify some characteristics that are essential to successful collaborations. These stories illustrate the potential and actual benefits of partnership, as well as some of the challenges that must be and have been confronted in sustaining close ties with academic partners.

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Introduction

The University Partnerships Office provides the leadership and the framework for execution of the Laboratories' university partnerships strategy, as well as leadership within the Nuclear Weapons Complex with respect to the role of university partnerships in supporting Complex Transformation. This Office executes the strategy primarily through management of the Campus Executive Program, the umbrella under which corporate investments in research, recruiting, and education are aligned with the Campus Executive universities. The University Partnerships Office manages several other university-related programs including the Graduate Research Program, Presidential Early Career Award for Scientists and Engineers (PECASE), and the Sandia University Research Program (SURP). A major area of emphasis for the program includes further development of the partnership between Sandia and the University of Texas System as well as managing the Truman Fellowship Program. Through these programs, Sandia invests in students and faculty via contract research and graduate research projects. These investments are intended to help accelerate the creation of world-class research, produce future generations of scientists and engineers, and grow competencies and new businesses for Sandia.

Numerous possibilities for collaboration with external scientists and engineers exist at national laboratories. Despite the large numbers of talented individuals within national laboratories such as Sandia, it is improbable that any one institution — particularly one pursuing such a breadth of science and engineering (S&E) — could bring together either all the experts or all the creativity of early-career researchers in a given discipline. Hence, Sandia actively seeks such collaborations. This is particularly true for invigorating research efforts important to the maintenance of cutting-edge creative ideas and capabilities crucial to national security, where there is no shortage of competitors. It is no secret that such competition requires a strategic focus. This is true whether the arena is enhanced energy efficiency or methodologies with which to thwart weapons of mass destruction.

Sustaining this leading edge is an attitudinal disposition consonant with Sandia's Laboratory-Directed Research and Development (LDRD) program, which, in part, funds academic research collaborations. But beyond such individual research projects is also a broader mandate, the desirability of forging and sustaining ongoing relationships with universities, which in their resonance with Sandia's national security objectives can serve as bidirectional resources. Beyond the research itself, such relationships can establish an ongoing exchange of ideas and, in certain instances, a source of new staff, on both short- or longer-term bases.

Any review of the refereed scientific literature — and of certain stories within this publication — will indicate that many breakthrough ideas and technologies originate with academic scientists and engineers. Because they are continually vying for research-program funding, and the highest-quality available students, eliciting collaborative ventures from academic scientists can be a complex and difficult endeavor. It is frequently the case that academic researchers are familiar with the work of Sandians — and vice-versa — through the scholarly literature and via direct contact at scientific meetings. This can also include reciprocal invitations to visit Sandia or the university and present colloquia on a particular research effort. Although such encounters and colloquia are often quite helpful at initiating collaborations, they are not always adequate to create enduring partnerships.

This report focuses the light of relationship on those gems, and a dazzling spectral array emerges, with elements of both collaboration, mutual exchanges of expertise, and perhaps most important, a conduit supplying new research talent to a national laboratory that must continually revitalize its workforce to remain at the leading edge. From the graduate student who had no

Our university collaborations are important because they stimulate new ideas and thinking at Sandia from the perspective of the academic community. These interactions also help the universities to think in new ways about the needs of the national security community. The universities serve as a pipeline for the next generation of Sandians and the next generation to advance our capability base. Thus Sandia benefits greatly from our investments in university research.

J. Charles Barbour,
Deputy to Vice President for Science, Technology, and Engineering

notion of the diversity and quality of national laboratory research to the one who never expected to have access to such remarkable tools; from the academic researcher who recognizes the remarkable commitment and dedication of Sandians to national security to the one who is inspired to develop that same commitment; from the young university faculty member who is recognized as a potential lifelong friend of the Laboratories to those faculty whose laboratories continue to serve as conduits to bring the best and the brightest young researchers face-to-face with the potential that Sandia provides; from the immense range of engineering capabilities that Sandia offers to academic partners to the diversity of theory and practice that universities present to a national laboratory that couldn't possibly develop expertise in every aspect of every scientific subfield: these are the stories told in this publication. These are the framework timbers around and atop which Sandia-university collaborations build a structure of the type that Presidents Franklin Roosevelt and Harry S. Truman envisioned when their science advisor, Vannevar Bush, proffered the notion that federal support for universities and national laboratories was a crucial element of both the facilitation of scientific R&D and the training of future generations of scientists.

Now, more than ever, with other countries forging ahead by fueling their own S&E research, with the United States (US), by some educational measures, lagging behind, it is crucial to promote collaborations between the nation's universities and national laboratories like Sandia. In tangible terms, payoffs can be measured by new staff hires, and by research dollars invested into both parties by agencies such as the National Science Foundation (NSF), the National Institutes of Health (NIH), the Department of Defense (DoD), as well as in User Agreements with university partners, such as those encompassed in the Center for Integrated Nanotechnologies (CINT).

Typified in many of the narratives in this report is an overall theme exemplified by the cover of this publication, either directly articulated or alluded to by the individuals involved in these Sandia research collaborations. It is simply that collaboration extends far beyond strictly the bounded parameters of a particular research agenda. Often those new vistas are surprising, provoking a shift in awareness about the fantastic breadth of research activity ongoing in a national laboratory environment such as this one, and just as often, they are connective, forming routes to additional collaborations, both intra- and extramurally. Because of this phenomenology, the return-on-investment for a particular university collaboration can often extend beyond papers published or additional grants funded — and can return benefits for extended timeframes.

Campus Executive Program

Sandia has as its highest goal to become the laboratory that the US turns to first for technology solutions to the most challenging problems that threaten peace and freedom for the nation and the globe. University partnerships are a critical element in achieving this goal. Sandia has traditionally contracted for university research to expand its science and technology base to ensure the performance of its nuclear weapons. However, opportunities exist beyond this status quo. Both Sandia and universities share a need to accelerate the creation of world-class research, produce scientists and engineers, and grow competencies and new businesses. Today, Sandia partners with key universities to achieve three major objectives: conduct world-class science, hire world-class scientists and engineers, and develop strategic collaborations in focused research areas.

Both Sandia and universities share a need to accelerate the creation of world-class research, produce scientists and engineers, and grow competencies and new businesses.

The Sandia Campus Executive Program was established in 1997 as a means to help accomplish these objectives. It provides a framework for Sandia to focus its research goals and helps create the 21st Century workforce needed to perform the technical jobs crucial to fulfilling its national security mission. Sandia executives, acting in the role of ambassadors, are paired with top university officials (usually vice presidents of research and/or deans) at schools that have synergistic research interests and capabilities with Sandia. These Sandia executives are tasked with the responsibility of working with the universities to implement programs established for the express purpose of furthering the goals of both Sandia and the universities.

This program encourages the Campus Executives to work with their university counterparts to develop strategic partnerships that, if achieved, satisfy the needs of each institution. They employ an integrated investment approach whereby research, talent, and advocacy needs are pursued simultaneously, not independently. The Campus Executives schedule visits to their assigned universities once or twice each year, serve on university advisory boards, and attend special events. They interface with campus recruiting teams to actively support placing students in the numerous Sandia programs. The Campus Executives also interface with university faculty to promote sabbaticals, placements, and exchanges. This program enables the Campus Executives to deliver a coordinated message to educate key university personnel regarding the infrastructure and programs being put in place to mutually benefit both Sandia and its strategic university partners. In 2009, 21 universities were considered the corporate supported universities with which campus executives interacted.

Campus Executive assignments FY09

University	Campus Executive	Deputy Campus Executive	Research Focus Area
Caltech	Gerry Yonas	Tim Shepodd	Cognitive Neuroscience
Carnegie Mellon	Vacant	Larry Shipers	Computer Science/Robotics
Cornell	Gerry Yonas	Jonathan Custer	Cognitive Neuroscience
Georgia Tech	Jill Hruby	Dave Womble	Microsystems Research
MIT	Jim Woodard	Gerry Sleefe	Infrastructure Surety
New Mexico State University	Steve Rottler	Anthony Medina	Water Research
New Mexico Tech	Jim Chavez	Paul Shoemaker	Explosives/Energetic Materials
Purdue	Joe Polito	Marcey Hoover	Nanotechnologies & Microsystems Res
Stanford	Joan Woodard	Glenn Kubiak	Materials Mechanics Modeling
Texas A&M University	Les Shephard	James Peery	Global Nuclear Security
University of Arizona	Duane Dimos	Ray Finley	Water Systems Modeling
University of California at Berkeley	Terry Michalske	Blake Simmons	Microsystems Research/Energy
University of California at Davis	Len Napolitano	Mike Hardwick	Info Security/Embedded Reasoning
University of Colorado at Boulder	David Plummer	TBD	Microsystems Research
University of Florida	Tom Hunter	Regan Stinnett	Micro/Nano Science & Engineering
University of Illinois at Urbana-Champaign	Dave Carlson	Russ Skocypec	Nano Science/Cognitive Neuroscience
University of Michigan	Bob Carling	Brandon Levey	Microsystems Research
University of New Mexico	Rick Stulen	Rob Leland	Nano Science & Engineering/ ModSim
University of Texas at Austin	Jerry McDowell	Art Ratzel	Nano Science & Engineering
University of Texas at El Paso	Gil Herrera	Ernest Garcia	Advanced Manufacturing
University of Wisconsin	Paul Hommert	Mark S. Allen	Nuclear Eng/Computational Sciences

The three Campus Executive partnerships reported in this section exemplify successful efforts at both collaborative research and staff recruitment. Although others could have been chosen, these three are illustrative of the types of activities and interactions that serve both Sandia and its partner universities well.

Watching an Orchard Bear Fruit

Rodney Wilson, Campus Executive
Russ Skocypec, Deputy Campus Executive
University of Illinois at Urbana-Champaign

"...the theory by which this partnership flourishes is all about relationships."

Dedication, enthusiasm, and teamwork driven by an esprit de corps: these are unquestionably the key traits that characterize the 19 Sandians who currently give of their own time and energy for the purpose of sustaining what can only be characterized as an intimate working relationship with the University of Illinois at Urbana-Champaign (UIUC). Led by Campus Executive Rodney Wilson and Deputy Campus Executive and recruiting team lead, Russ Skocypec, the theory by which this partnership flourishes is, according to Skocypec, "all about relationships."

This is not simply a hypothesis, but deserves the status of theory given the testing it has withstood over an almost 15-year tenure. With over 200 UIUC alumni already employed by Sandia, 10 additional full-time UIUC new hires joined the Laboratories, 5 of them PhDs, in FY 2009, alone. More than simply a one-way flow stream from Illinois to New Mexico or California, the partnership is entirely reciprocated, as Sandia seeks collaborative research endeavors with virtually any UIUC research arena that coincides with mission priorities. Key thrust areas are identified, then reviewed and assessed at an annual Sandia-UIUC board meeting. Building upon longstanding collaborations in materials science and modeling and simulation, recent important areas of collaboration include cognitive neuroscience, nuclear engineering, complex systems and system of systems, and nanoscience (UIUC is a partner in the Sandia-led National Institute for Nanoengineering [NINE]).

"Sandia doesn't give money away," emphasizes Campus Executive, Rodney Wilson, the comment meant to indicate that the partnership is built around common research interests that benefit both institutions. A 2007 memorandum of understanding (MOU) was signed to streamline the collaborative process, ensure that worthy scientific collaborations do not drown in a sea of red tape. According to Wilson, this MOU "elevates the relationship to pay close attention to research areas in which both institutions have interest. Our job, then, is to get someone involved from each side." Once that is accomplished, subsequent steps in actually establishing a joint research program are much easier. In a partnership of this type, mutually beneficial research endeavors can be greatly facilitated by shorter- or longer-term exchanges of early-career personnel. With Sandia staff members and UIUC faculty the bridge across which collaborative ideas and exchanges of research results ensue, graduate students and postdoctoral students can represent equally

Over 70 Sandia employees, alumni of UIUC, enthusiastically gathered for this group photo to assert their pride in that connection. Even more remarkable is what is lacking from this photo: this group does not even constitute half the total number of UIUC alums (over 200) employed by Sandia.

important traffic across that bridge, adding a creative human component to the research, making it more likely that important outcomes are more thoroughly and fruitfully shared.

For example, working as a Summer 2009 intern in the laboratory of Sandian John Eddy, current campus executive graduate research student Conrad Tucker (see page 13) made significant contributions to the Sandia group's system of systems analysis, helping to strengthen the partnership in this area. In turn, Eddy traveled to UIUC in the Spring of 2010 to present a seminar on this work at the leading edge of computational systems analysis. On the one hand, Conrad Tucker helped Sandia in its effort to discern patterns and discover behaviors that it is attempting to mitigate in military systems in order to better predict failure rates. On the other, Tucker brought back his "better grounded" experience to the laboratory of Professor Harrison Kim at UIUC, with real-world, national security applications that brought into focus the importance of the research.

Moreover, Tucker's enthusiasm about his Sandia summer will undoubtedly spread virally through the ranks of his colleagues, both in his own laboratory and others. As pointed out by Wilson and Skocypec, this one-on-one contact and its infectious propagation serves as an eye-opener for other graduate students at the university, informing them of the availability and the educational and career value of a Sandia internship. Such is the type of pipeline that ultimately makes it possible for Sandia to attract significant numbers of talented staff from UIUC.

Exemplary is Sandia staff member, Laura Matzen, hired in the important national security area of human cognition analysis, where modelers and psychometricists are making inroads into a relatively young field that is attempting to employ a number of different brain-imaging and computational techniques to categorize, predict, and quantify threats to national security from individuals and groups across the globe. By deducing, for example, patterns in speech and written texts that can assist intelligence analysts to identify threats of various types, this interface of cognitive neuroscience and computer science is clearly serving the Laboratories' national security mandate.

A chemistry major as an undergrad, who had worked several summers at Sandia, Matzen changed her graduate school area of interest to cognitive science, and through contact with the UIUC recruiting team, discovered the campus executive graduate research program. Despite the fact that it was an engineering call, Laura applied, and her successful application provided her support for three years of her doctoral program, working with Sandian Travis Bauer on human speech. In addition, the intellectual freedom conferred by the support enabled Laura to significantly expand her horizons, and her doctoral thesis included work from the laboratories of three different faculty members at UIUC. "I got to do lots of exploration," she says of what she clearly views as a completely enriching experience.

Laura had always pictured herself as an academic, a professor at a major research university, like UIUC, and this image persisted through her first three years of graduate school. But gradually, as she communicated with Bauer and other Sandians, and observed some of the situations surrounding her, she recognized several factors that moved her toward a career as a Sandia staff member. She attended several dinners given by the UIUC recruiting team; "I knew the purpose was recruiting," she observes, but despite that realization, she initially clung to her academic aspirations until she weighed all factors. The growth in Sandia cognitive science research, particularly its collaboration with UIUC, was a motivator, as was her desire to focus her energies on research, rather than teaching and other aspects of an academic career. Her decision has been quite satisfying. She is principal investigator (PI) on an LDRD project, which will bring an electroencephalography (EEG) capability to Sandia, closely working with UIUC faculty member Kara Federmeier, in a study of the brain's hippocampus and memory formation and a new phenomenon in the EEG of patients that may potentially be predictive of ways to improve memory. "This is exciting, really promising," Laura says. A new collaborative project with Laura as Sandia lead is just beginning with noted UIUC faculty member, Neil Cohen, and graduate research program student participant, Patrick Watson.

These collaborations bring Sandia even closer to UIUC's Beckman's Institute, playing

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"We need future Sandians comfortable in multiple domains"

"We plant the seed... and then step out of the way"

into strengths from both institutions, according to Rodney Wilson. Beckman is a highly multidisciplinary institute whose purpose is to collaboratively link researchers spanning the natural and the social sciences. It is an immense and self-funded (through an endowment from Arnold and Mabel Beckman and the State of Illinois) undertaking. Its National Center for Supercomputing Applications (NCSA) now offers a new supercomputer named "Blue Water," which is poised as a petaflop (a quadrillion or 10^{15} computational operations per second) machine. A recent MOU with Sandia's Org. 1400, Computation, Computers and Math, focuses on the next-stage progression to exascale computing (a quintillion or 10^{18} operations per second). Wilson points out that Sandia's codes and its vast modeling capabilities will be of great value to the Beckman Institute's powerful new hardware, and there is a planned collaboration around a cyber defender program to enhance cyber security, protect cyber resources, and safeguard data.

Several central research themes at the Beckman Institute are resonant with current Sandia growth initiatives such as biomedical imaging and infectious disease diagnostics. Beckman's incredibly diverse and integrated multidisciplinary environment mirrors some key elements of Sandia's own multidisciplinarity, and in that sense, there is a natural synergy between the research environments. "There are just so many strong alliances," as Skocypec frames it. "A national security laboratory is about multidisciplinary teamwork. We need future Sandians comfortable in multiple domains," he adds, offering a reason for his enthusiasm about the success of the UIUC/Beckman recruiting effort. This effort is so well organized that the recruiting team with the yeoman efforts of Staci Dorsey, who provides assistance to the UIUC campus executive effort, has set up a SharePoint site, which helps coordinate and track the recruiting. By posting Sandia job openings, the site helps guide recruiters to search the UIUC landscape for students who might fit a given position and assists recruiters in promoting specific careers at Sandia. Recruiters are also Sandia technical staff members, and to enhance this search for talent, recruiters are encouraged to give formal or informal "tech talks" when they visit the university, bringing their own work alive in meetings with students and postdocs; this continues to strengthen the partnership in myriad ways. The pragmatism of the recruiting effort is likewise reflected in the fact that recruiters of different ages are often paired, so that the younger recruiter of a pair will be able to help younger UIUC staff candidates with more mundane but sometimes daunting issues, such as housing, particularly for someone considering relocation from the Midwest to Albuquerque. In Conrad Tucker's case, this outreach even extended to the issue of ethnicity, as the recruiting team introduced him to members of the African-American community in the city.

A "self-generated network" is the way Skocypec characterizes the current situation, which generated 90 résumés and 50 potential hires in FY 2009. "We plant the seed . . . or the sapling . . . and then step out of the way," he modestly proffers. And while this may, to some extent, be true, it is also obvious that years of tilling and fertilization have occurred to create a model for what a win-win university partnership should look like.

Implementing a Diverse Strategy

Jill Hruby, Campus Executive
David Womble, Deputy Campus Executive
Georgia Institute of Technology

For Campus Executive Jill Hruby and Deputy David Womble, the Georgia Institute of Technology (Georgia Tech) represents a gold mine of engineering talent, a unique collection of bachelors, masters, and doctoral candidates, who have, historically, contributed a great deal to Sandia's capabilities and its culture. With just short of one hundred Sandians proudly declaring themselves Georgia Tech alumni, and with 19 regular staff hires of Georgia Tech alumni during the four-year period, FY 2006–2009, the campus executive team is obviously quite serious about its recruiting efforts. "Lots of credit to the full team," Womble is clear to emphasize; "it does take a conscientious effort on the part of Sandia."

As indicated by the story of campus executive graduate research student, Jay Lofstead and his advisor, Professor Karsten Schwann, (see page 15), Sandia is certainly doing something right — something that is serving to distinguish itself as a desirable place with which Georgia Tech faculty are enthusiastic about collaborating, and toward which its students are happy to migrate for the purpose of enlarging their experiences. Nor are these collaborations limited in their scope or variety. For example, Lofstead, a computer scientist and his advisor, Schwann have collaborated in the arena of code construction for massively parallel computers, computational engineering, while in other instances, the partnerships have formed around materials and nanoengineering.

Georgia Tech faculty member, Professor Samuel Graham, was actually a Sandia staff member for four years, departing Sandia to accept the Georgia Tech faculty position in 2003, only because of a coalescence of circumstances that made the timing right. "I always wanted to be an academic, and I thought I'd only be at Sandia for one or two years," he recalls; "and I would've been happy there had I stayed." Using Raman scattering to very accurately measure temperature and its effect on stress in microelectromechanical system (MEMS) devices moved Graham's research career in new directions, "played a big role in where I am today," he says. Nor did he cut ties, collaborating on an LDRD project, from 2003 through 2006, from which Sandia gained a new staff member in the person of Graham's graduate student in the LDRD Project, Thomas Beechem, who came to Sandia after completing his doctorate in Graham's laboratory at Georgia Tech.

Although fraught with such stories of partnership, the Georgia Tech-Sandia collaboration also displays a more structured and cohesive set of initiatives to evidence the Laboratories' diverse opportunities to Georgia Tech undergraduate and graduate students, and thereby promote Sandia as a desirable place to work. Hruby and Womble oversee a team of about 15 Sandia staff, all Georgia Tech alumni, who serve as recruiters. Directly led by Brian Mileshosky, the recruiting team stays in close contact with Sandia Human Resources (HR), trying to anticipate Sandia hiring needs, which this past year have been focused in the cyber arena — computer and electrical engineering. According to Mileshosky, the team — which sustains ethnic and gender diversity — sees itself as a vehicle for connecting prospective candidates with Sandia managers. Many team members are early-career Sandians,

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The reality is that in a burgeoning field like cyber engineering, there exists an ongoing competition for the most qualified graduates, especially from an institution with Georgia Tech's strong reputation.

making it easier to connect with Georgia Tech undergraduates and grad students. Beyond loyalty to their alma mater, the Sandia staff members on the team contribute their time and energy because "they enjoy it and see where the benefit is for Sandia," comments Mileshosky.

"We're always trying new things," Campus Executive Hruby says, lauding the efforts of her recruiting team. In addition to what might be thought of as a more standard approach to providing exposure to Sandia research activities — such as the monthly seminar series on energy-related topics that Sandians delivered on the Georgia Tech campus in FY 2009, Hruby is excited about an alternative approach spawned by her team. Mileshosky describes it as the brainchild of spontaneity — the product of discussions among recruiters in their enthusiasm to bring a better-rounded picture of Sandia to Georgia Tech students. Sandia solves problems in national security, as Mileshosky points out, and so what better way to feature that aspect of the Laboratories, and what better way to look for problem-solving abilities in prospective candidates, than to connect recruiting with a problem-solving activity.

Planned and executed in conjunction with the university's chapter of IEEE (the Institute of Electrical and Electronics Engineers), this so-called "design competition" pre-enrolled four-member teams of advanced undergraduates and graduate students to propose a solution and present its critical thought processes with reference to an open-ended problem in the area of cyber engineering. A university faculty member served as one of the judges and prizes were awarded. More significantly, the recruiting team was able to bring back both résumés and more-in-depth reportage about some of the best Georgia Tech students in this engineering field. Returning such enriched personal information to Sandia managers via HR is what the recruiting team views as its primary mission.

There are so many natural connections between Sandia and what Womble characterizes the Southeast's premier engineering school that for Sandia not to score high on the list of career options for Georgia Tech graduates would be quite surprising. Exemplary is the Georgia Tech Research Institute (GTRI), which according to Hruby has a mission of transitioning technology from the university into the outside world, and which does considerable work for the Department of Homeland Security (DHS), a significant Sandia customer. While such commonalities and the significant alumni presence are strong ties that bind the two institutions, these connections are hardly a guarantee of success. The reality is that in a burgeoning field like cyber engineering, there exists an ongoing competition for the most qualified graduates, especially from an institution with Georgia Tech's strong reputation. Hence, as Hruby and Womble point out, a concerted conscientious effort really does require trying new approaches, while sustaining and strengthening existing research ties in palpable ways.

But the initiative extends even further. For Georgia Tech's location in the American south, within the city of Atlanta, makes it a gateway to minority engineering populations. In terms of producing African-American engineering graduates, the publication, *Diverse: Issues in Higher Education*, ranks Georgia Tech first in the nation, in terms of degrees awarded at the bachelors level for the 2007-08 academic year, second in the nation for engineering master degrees awarded to African-Americans. In recognition of these statistics, Hruby and Womble, together with the entire Georgia Tech team are committed to strengthening the focus on minority recruiting and hiring, with particular emphasis on African-American engineers.

This is, by no means, a trivial challenge. Although the benefits of Sandia employment are significant, Albuquerque's African-American community is relatively small, and retention of qualified African-American hires is an issue that HR is actively addressing. This recognition is echoed by Campus Executive Hruby, who refers to minority hiring as "a critical piece of our success." Sandia has sponsored conference/workshop events in conjunction with Georgia Tech's chapter of the National Society of Black Engineers, and there is a clear intent to continue the initiative along these lines as part of a recruiting goal that places a Sandia presence at a projected total of seven to eight on-campus events, annually.

Crystal Clear Partnership Objectives

Les Shephard, Campus Executive
Texas A&M University

After five years as the campus executive for Sandia's partnership with Texas A & M University (TAMU), former Sandia vice-president and current Director of the new University of Texas at San Antonio Institute for Conventional, Alternative and Renewable Energy (ICARE), Les Shephard struck and resonated a theme with many overtones, but whose primary message was: "For Sandia to be successful in the future, our relationships with universities are key."

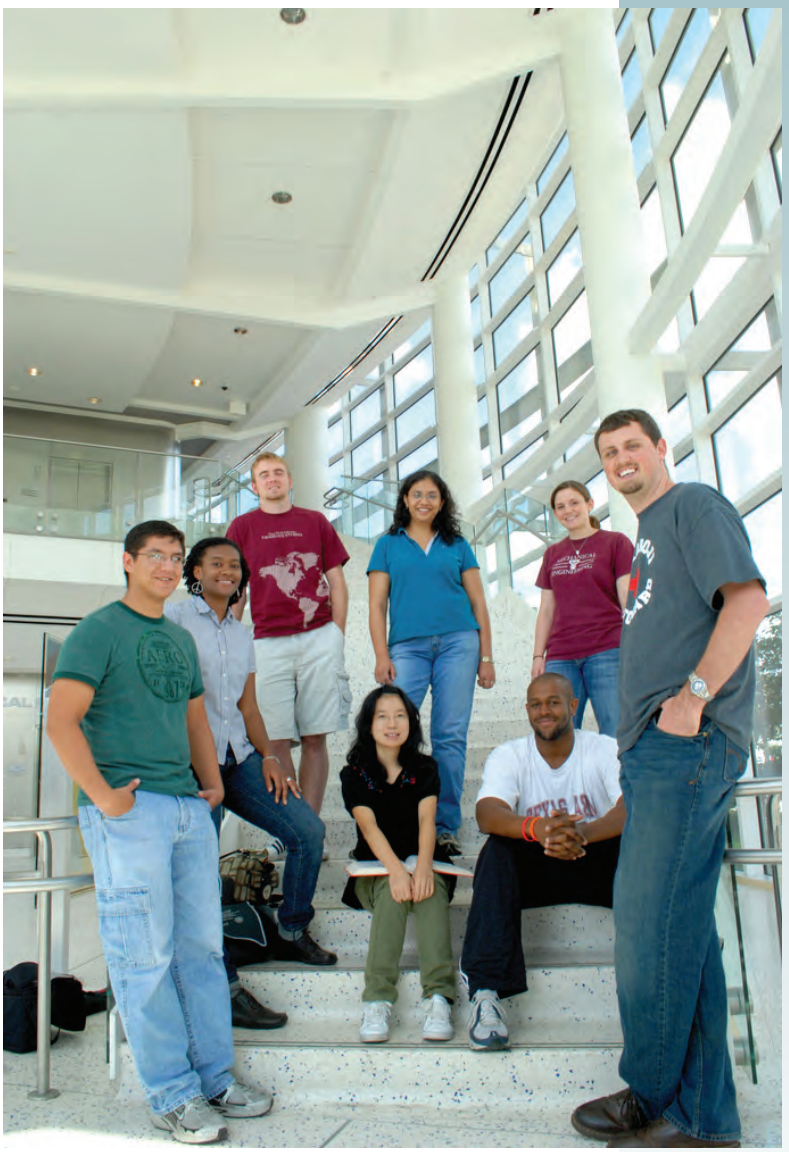
Shephard was hardly at a loss for specific approaches to such partnerships or for illustrative examples from his work with TAMU. He strongly believes that personal relationships between Sandians and a university are necessary. While admitting that alumni status could be useful, Les also discounted that as a necessity, pointing out that not all Sandians involved with TAMU held that alumni status. Far more important, he felt, was having Sandians serve on advisory councils for individual university departments. For example, at TAMU, James Peery, Sandia Director of the Information Systems Analysis Center (Org. 5600), serves on an advisory board for the Nuclear Engineering Department; Steve Rottler, Vice President and Chief Technology Officer (Div. 1000), to Engineering Sciences; and Shephard himself to Geosciences, his own area of study during his college years at TAMU.

"A personal relationship must exist at the department level," he affirmed, pointing out that the operational goal should be to identify points of contact in every natural science department whose work was germane to Sandia's mission. This type of multipoint involvement also made it easier to identify faculty who might benefit their own careers and Sandia's mission by spending summers and even sabbaticals at Sandia.

Specifically crediting Henry Abeyta, Director of the Global Security portion of Sandia's Energy, Resources, and Nonproliferation (ERN) Strategic Management Unit (Org. 6900), for his work in TAMU's Nuclear Safety and Policy Institute, Shephard emphasized that such individuals were largely "self-motivated," driven by a desire to strengthen the partnership. He commended these individuals as willing to invest even personal time in this endeavor, and he characterized Laboratories' executive leadership as "supportive" in allowing these individuals to travel to and spend time at the university for this purpose.

Ultimately, Shephard believes that this team approach to personal contact throughout the university's relevant departments is fundamental to a partnership, and he emphasized his personal relationship with former TAMU president Bill Gates and current president R. Bowen Loftin, as well as to the provost and vice-president for research. Such depth of relationship is and has been reflected in several ways. For example, during Hurricane Katrina's devastation of New Orleans, the city's Tulane University was necessarily closed, and TAMU offered its services to Tulane in terms of helping with relocating students so that their education

For Sandia to be successful in the future, our relationships with universities are key.



might continue. In turn, through TAMU, Sandia offered its assistance in temporarily relocating Tulane faculty to Albuquerque for experiences at Sandia; although the latter plan wasn't implemented as Tulane managed to reopen its doors, the possibility did factor into Tulane's strategy in terms of its options.

The TAMU partnership has had several tangible outcomes for Sandia. A number of Sandia staff are graduates of TAMU's College of Geosciences, whose atmospheric sciences program is one of the top-ranked in the US. Given global climate change and its relationship to shifts in the atmosphere, an ongoing potential for bringing TAMU graduates to Sandia is an important part of the Laboratories' staff recruitment initiatives. In the nonproliferation area, Shephard and Sandia targeted this topic as central to the partnership. Henry Abeyta and his team have worked with TAMU's Nuclear Security and Policy Institute to develop a curriculum around nonproliferation and to work together — and with Sandia's NA-20 (NNSA) customer — to seek opportunities for joint proposals to secure research funding. Already about a million dollars in funding has been secured, some of this money funding research by TAMU faculty in support of Sandia initiatives. Pete Miller, a former Los Alamos National Laboratory (LANL) staff member became part of this Institute shortly after his retirement from LANL; President Obama subsequently appointed Miller as DOE Principal Assistant Secretary for Nuclear Energy, a position from which Miller's awareness of the TAMU-Sandia nonproliferation partnership may well pay dividends. Overall Shephard characterizes such initiatives as "a way of funding very solid consensus constituencies where people have shared interest and commitment to their institution."

"...the most important commodity for Sandia, over the longer term, is students obtained through relationships with departments and their faculty, who may enrich Sandia in various ways..."

In Shephard's view, the most important commodity for Sandia, over the longer term, is students obtained through relationships with departments and their faculty, who may enrich Sandia in various ways — through graduate and postdoctoral fellowships, and most importantly, as new staff in key areas such as climate science and nonproliferation. He describes his outreach to one of the TAMU system's smaller colleges, Prairie View A&M University, a majority African-American satellite near Houston. Perceiving it as an investment in Sandia's future, Shephard went so far as to bring Prairie View students to Albuquerque one summer to introduce them, not only to Sandia, but also to life in the Southwest, as the first steps in a possible masters fellowship program. Working with Sandia's Black Leadership and Outreach Committee, and particularly citing Sandia staff member Chris Collins, Shephard recruited individuals from Albuquerque's African-American community to assist in orienting these minority students to the possibility of living and working in New Mexico. He portrays this as using TAMU as a "mothership . . . a pipeline for becoming engaged with minority-serving institutions," and he advocates this strategy as an important one for Sandia.

More globally, Shephard believes that Sandia must develop an integrated strategic approach, being "crystal clear about what this means to the Labs . . . why it's important and what commitment we're willing to make." He credits University Partnerships' consultant, Juan Abeyta, for recruiting support. While he thus advocates a bit more formality to partnerships in those senses, Shephard shies away from overly prescribing structures for such relationships, standing by his core belief that it is the "willingness of people to build relationship" that remains the key element of success.

Sandia must develop an integrated strategic approach, being "crystal clear about what this means to the Labs . . . why it's important and what commitment we're willing to make.

Graduate Research Program

The On-Campus Graduate Research Program process was implemented at Sandia in 2001 as a means to leverage research investments at its Campus Executive universities. It enables Sandia to establish strong connections with schools that are doing research in areas of strategic importance to the Labs. Sandia also believes that these research projects are a means to establish stronger relationships with the students so that at the conclusion of their PhD work, they will look more favorably on employment at Sandia. The deans of graduate schools see this program as a means to attract great students into their departments.

Each Campus Executive has $50k of Laboratory Directed Research and Development (LDRD) funding earmarked for investments in either graduate research projects or contract research at their university. Based on the plan developed for each university, the Campus Executive determines the appropriate investment of that money. At some schools, the Campus Executive, working with the deans of engineering, arts and sciences, or computer sciences may employ the strategy of establishing graduate research projects for doctoral students doing research in areas in which the Labs has strategic alignment. In these instances, the student and a Sandia Principal Investigator are matched to identify a research project and conduct the research. In many cases, the Sandia Principal Investigator or the Campus Executive becomes a member of the student's doctoral committee. With the Sandian on the doctoral committee, the Labs not only builds relationships with other professors but also is able to offer direct input in the research direction. The desired result of these research projects is to develop a long-term relationship with students that show promise of becoming future Sandia employees, educated and trained in areas of importance to Sandia. At other universities, the Campus Executive elects to invest his/her money in a research project as a means to "seed" an area that looks promising, with the strategy of Sandia and the university eventually collaborating for third-party funding.

The four stories presented herein illustrate the productive experiences of graduate students of the three featured Campus Executive schools, plus a fourth story from Purdue, another Campus Executive partnership. Two of these four individuals are now employed at Sandia as postdocs, a third has accepted an invitation to interview for employment, and the fourth is strongly considering application upon receipt of his PhD.

Research projects are established with each graduate student fellow in areas of need and strong mission alignment with Sandia's technical areas of research.

A Tree of Interaction

Conrad Tucker, University of Illinois at Urbana-Champaign (UIUC)
John Eddy (Org. 6342), Sandia PI

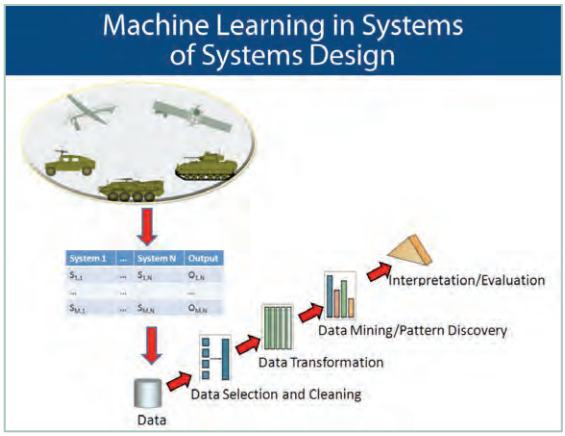
For Conrad Tucker, the road to Sandia as a graduate fellow in the UIUC partnership (see page 6) was both a rich and a tortuous one. Fortunate — by his own assessment — to have benefitted from a portion of the 1999 one billion dollar grant to higher education from the Bill and Melinda Gates Foundation, Conrad was able to finish a BS in Mechanical Engineering from the Rose-Hulman Institute of Technology in Indiana. But a year out in the workforce convinced him that he wanted more than simply the implementation side of engineering, and it motivated him to seek graduate study that would expand his theoretical base. Such was his introduction to UIUC and his advisor, Professor Harrison Kim, in pursuit of a Master of Science degree. But a PhD program with Kim, together with a part-time MBA program beckoned Conrad onward, and his advisor apprised him of the opportunity to even more broadly enhance his experience by applying for the Sandia graduate research program.

At the other end of this collaboration, Russ Skocypec, the UIUC Deputy Campus Executive, had assessed that of two UIUC graduate students whose applications seemed a fit with various aspects of Sandia science, Conrad's experience and PhD research appeared to be a better alignment to an Org. 6342 LDRD project led by Principal Investigator (PI), John Eddy and

Conrad Tucker, UIUC

Conrad was able to maximize his Sandia summer experience, during which, he availed himself of opportunities to attend seminars and colloquia on a diversity of topics, both near and farther afield of his research.

Program Manager (PM), Bruce Thompson. The project's focus, to optimize system-of-systems modeling and predictive capabilities, particularly in the future combat systems arena was poised to derive benefit from Conrad's background in both data mining and multidisciplinary design optimization, particularly analytic target cascading, a method for decomposing complex systems into a hierarchy of subsystems. Meanwhile, the complexity of the Sandia project was fertile ground for seeding Conrad's doctoral research with a project that provided "opportunities to see how theoretical models had direct relevance and real-world applications."



Conceptual representation of research using data from military systems to attempt to understand, evaluate and predict reliability

"This grounded my experience," Conrad offers about the project. "John was instrumental in identifying application areas relevant from Sandia's perspective," he notes, while praising his advisor, Dr. Kim, for sustaining his developmental path in theoretical aspects and facilitating the generation of scholarly publications.

From Sandia's perspective, this collaboration brought forth an interesting expansion of activities, for a project aimed at modeling complex military systems for which, according to Eddy, the goal is to "discern patterns and discover behaviors that you want to mitigate." Using Sandia's SoSAT (System-of-Systems Analysis Tool) software, the idea is to create statistical models of reliability and logistics for military platforms and supply chains and run simulations that can ultimately tell customers over the mission life of a particular platform, what percentage of time they would be likely to fail. This normally represents gigabytes of data from which the project researchers try to make sense in terms of risk analysis, and which ultimately, perhaps, can progress toward optimization, where they can suggest solutions that might improve reliability. In the midst of this research activity by Eddy and his collaborators, Conrad built a hierarchical decision-tree, whose root inputs could be traced upward to estimate probable outputs (outcomes) up the tree branches, without actually running the model computationally. "It raised a lot of eyebrows, was very useful information for us, with a great deal of potential to enrich our efforts," Eddy affirms. This interest even stimulated a member of the Sandia research team to submit an LDRD proposal. "It was good experience certainly for me, and I hope for Conrad," Eddy concludes.

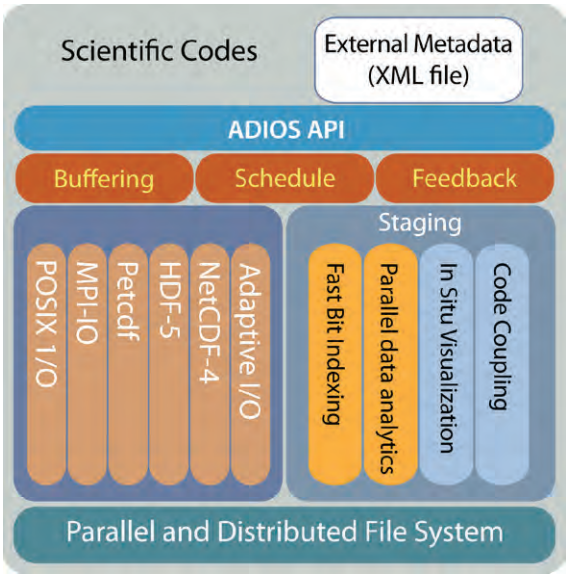
Such indeed seems to have been the outcome. For beyond his research with Eddy's group, Conrad was able to maximize his Sandia summer experience, during which, he availed himself of opportunities to attend seminars and colloquia on a diversity of topics, both near and farther afield of his research. "It's important to see what people are doing in other fields," and "I tried to get as much of Sandia's experience as humanly possible in three months," he admits, becoming yet another awed voyeur into the Laboratories' vast breadth of science. Clearly, for Conrad Tucker, the experience left its very positive mark: "I would definitely recommend not only the program, but also the actual experience at Sandia, over the summer . . . which was very important to me . . ." he says " . . . meeting people who have dedicated their lives to national security." Seeking a postdoc or a staff position at Sandia after he defends his dissertation remains a definite possibility in Conrad's thinking.

Growing a Multidimensional Partnership from a Single Seed

Jay Lofstead, Georgia Institute of Technology (Georgia Tech)
Ron Oldfield (Org. 1423), Sandia PI

It is somewhat ironic that a piece of software (more-precisely, "middleware") called ADIOS (Adaptable IO System) would end up having an effect more consonant with "benvenidos" (welcome). Linguistic irony notwithstanding, that welcoming to partnership has, decidedly, been the net effect of the ADIOS project, stemming from the more global Sandia relationship with Georgia Tech. In addition to strengthening that partnership, ADIOS has formed the center of additional university and national laboratory collaborations.

"I always saw this as seed money for bigger projects," presciently observes Sandia PI Ron Oldfield. "Karsten said he had a good student," he recalls of a conversation with Professor Karsten Schwan of Georgia Tech. Oldfield was acquainted with Schwan through a relationship between their graduate school advisors, through contact at professional meetings, and through the ongoing diversity of the Georgia Tech-Sandia partnership, particularly one aspect of it that brought them together on DOE's ASCR (Advanced Scientific Computing Research) Program. Oldfield was aware of campus executive funding for graduate research projects and apprised Schwan of the possibility,



Conceptual representation of elements of the ADIOS software

that conversation becoming the support base for bringing Schawn's "good student," Jay Lofstead, into a collaborative research arrangement between Sandia and Georgia Tech for his doctoral thesis research. Out of school since his 1993 BS from Georgia Tech, Lofstead had always wanted to pursue graduate study, but had found that course financially daunting, instead working in computational simulation and automation for several large corporations. Returning to Georgia Tech in 2004, Jay was apprised by Schwan of the Sandia graduate research program possibility.

A key aspect of ADIOS is its ability to assist in most efficiently getting input data to the processors of massively parallel supercomputers like Sandia's Red Storm. Many applications for these machines — for example climate simulation or combustion codes — are "write-intensive," their data libraries inefficient at writing (inputting) data to the machine's thousands of processors. A method to improve data quality, its processability would be a great asset because input-output (I/O) issues often prevent such applications from taking advantage of the hardware's full processing capabilities. ADIOS decides how data files are best placed into a proper destination format. In addition, researchers have found it invaluable for scaling I/O to the number of processors utilized on a massively parallel machine. ADIOS makes it easier to adapt I/O and to, therefore, port applications to different machines in the DOE complex, such as Lawrence Livermore National Laboratory's (LLNL) Blue Gene L and Oak Ridge National Laboratory's (ORNL) Jaguar. "You get more science out of a machine," as Jay Lofstead frames it.

Lofstead actually spent a summer at ORNL, in addition to several summers at Sandia, during which, according to Oldfield, he spent his weekends investigating the entire state of New Mexico. Oldfield credits ADIOS with improving the relationship between Sandia and ORNL. A Sandia team, collaborating with Scandinavian researchers, and faculty from Georgia Tech, Rutgers University, and other

"Working with Sandia has been extremely pleasurable...such a professional organization."

Jay Lofstead, Georgia Tech

universities is working with researchers at ORNL on combustion codes. Meanwhile, both Sandia and ORNL are vying for Jay Lofstead's services as a staff member. "Working with Sandia has been extremely pleasurable . . . such a professional organization," Lofstead says of his interface with Sandia. "Everything is focused on doing the right thing and doing it safely," he adds. Hopefully those sentiments are a harbinger of things to come, as Oldfield would wish to see the full blooming of the growth from that seed by having Lofstead come to Sandia. Meanwhile three other student interns from Georgia Tech are working at Sandia's Computer Science Research Institute (CSRI), representative of the continued growth in richness of that partnership.

Regardless of any other outcome, Lofstead proclaims his dedication to sustaining the Georgia Tech-Sandia pipeline, pledging, "whatever I can do to make that happen."

Beneficial Outcomes from a Broad Partnership

Andrea Hsu, TAMU

". . . a really collaborative atmosphere."

Andrea Hsu, Texas A&M University (TAMU)
Jonathan Frank (Org. 8351), Sandia PI

Looking back on her decision to abandon her original interests in polymer chemistry and become involved in the study of non-thermodynamic-equilibrium high-speed flow imaging, Andrea Hsu sees a path that has led her to what she characterizes as an immensely enriching experience at Sandia. Encouraged by her TAMU advisor, Simon North, to apply for a Sandia graduate research program, she, hesitatingly, followed his advice, reasonably sure that nothing would come of it. But despite a topical call that did not appear to be perfectly aligned with the central focus of her research, Andrea's quality as a student and researcher were evidenced in her selection for the program. Having spent a year in industry after her undergraduate education, Andrea had been determined to improve her theoretical foundations, and after meeting North, had become excited about bringing her chemical engineering background into the aerospace arena. Ultimately, that combination of ingredients also brought her to Sandia.

At the Sandia end of this partnership, Campus Executive Les Shephard consulted with a TAMU faculty member who had previously done postdoctoral research at Sandia. This individual identified Andrea as an outstanding prospect. Shephard subsequently touted Andrea's graduate studies to Jonathan Frank, Org. 8351, whose research in this fundamental area of reacting flows at the Combustion Research Facility (CRF) is part of a Sandia effort to characterize and predict important aspects of the engineering and chemistry of combustion devices — from automobile engines to jet flows and beyond. Frank saw Andrea's research at TAMU as "complementary" to his own, and he invited her to work at Sandia for a few months to enrich her understanding and experience her graduate research in the context of the larger world of Sandia's initiatives in this key arena for energy efficiency and security.

"Just a great facility . . . gave me a chance to see state-of-the-art technology," Andrea says of her month at Sandia, which, other factors in her life permitting, "would have been longer." But even that period of time gave Andrea an opportunity to "build connections," as well a to obtain Jonathan Frank's help with image-

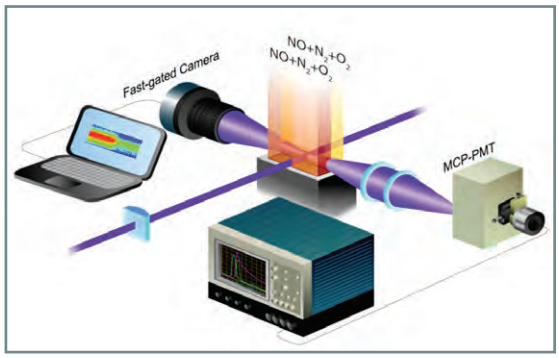
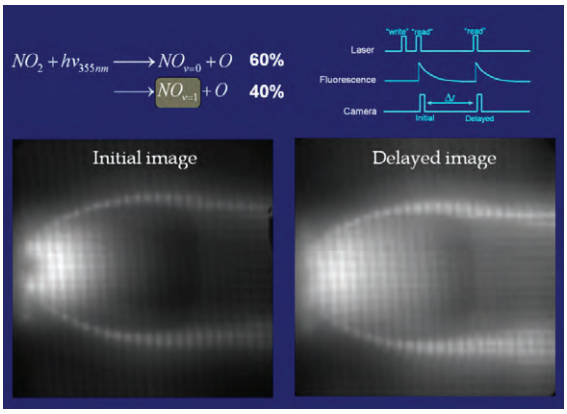


Image capture apparatus capable of picosecond resolution.



Captured images of the chemical dissociation of oxides of nitrogen.

processing software she was writing. Moreover, that month provided an opportunity to closely interact with other individuals at the CRF, from whom she gleaned invaluable technical experience about laser imaging, and imaging devices able to capture events on picosecond (one-trillionth of a second) timescales. "We just didn't have equipment like that," Hsu reflects. From her standpoint, this represented valuable expertise that she could bring back to TAMU. Moreover, she was positively impacted by the collegial atmosphere at Sandia, which convinced her that it was her first choice for a postdoctoral experience: "During my visit, I was really impressed by how friendly people were . . . a really collaborative atmosphere." From Frank's standpoint, Andrea made a useful contribution to imaging diagnostics helping to move his research forward, and she was included as an author in a poster presentation on the research.

From Sandia's standpoint, the Laboratories acquired a postdoc, with knowledge and skills potentially more focused and relevant than might have been the case for someone without Andrea's background and training. Frank characterizes her as a "very good postdoc," and reflects on the utility of the graduate research program in identifying someone of her quality as a postdoctoral possibility, thereby making it easier for him to find research talent. And Andrea's opinion of her work environment has, if anything, been reinforced. "On a day-to-day basis," she notes, "if I need anything, I feel like I can just walk down the hall and ask, and everyone will try to be helpful." At this juncture, her continued contribution to Sandia appears potentially open-ended, and she would "absolutely recommend" a Sandia graduate research project to any potential applicant, her wish being that she could have "passed it on" to a beneficiary, once she had completed her PhD.

Great Background References

Laura Biedermann, Purdue
Steve Howell (Org. 1748), Sandia PI

For Sandia PI, Steve Howell, the desirability of working with Purdue graduate student, Laura Biedermann was obvious both from her work and from her work environment. Studying and conducting research in the laboratory of Steve's former Purdue advisor, Dr. Ron Reifenberger, Laura was certain, in Steve's mind, to have developed a research ethic that included learning the intricacies of instrumentation and its application from the ground up, and therefore, at a fundamental level. In addition, during an introductory face-to-face conversation and several subsequent ones, it became evident to Howell that Laura was developing expertise in the areas of manipulating carbon nanotubes and in graphene epitaxy (growing single-layered graphite, an ordered, layer of carbon atoms on other substrates) that appeared to be potentially quite valuable to Howell's research. Facilitated by the Purdue administration, Laura's successful application for a graduate research project with Sandia placed her squarely at the center of a key nanoscience research area whose potential outcomes — in addition to fundamental scientific understanding — lie in the future possibility of novel sensors, integrated circuitry, and even new sorts of microelectromechanical system (MEMS) devices.

"When I met Laura, she wasn't so interested in working at Sandia," Howell recalls. And Biedermann confirms that it was mostly the

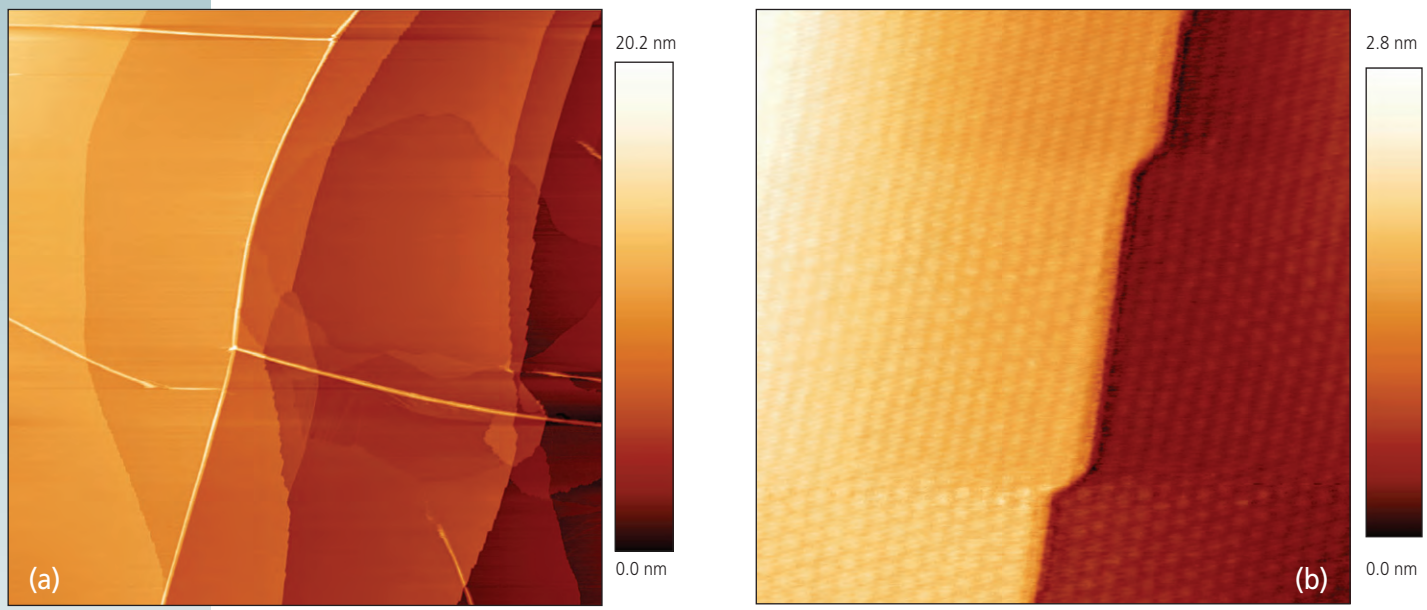
Laura Biedermann
Purdue

"I hadn't considered a career at a national lab before I came to Sandia."

Biedermann's graduate-work-derived publications are reflective of the expertise she acquired with graphene, the very expertise that is now a key asset to Sandia.

attraction of Howell's "outside perspective and engineering experience" that initially pointed the way to the utility of a collaboration. Steve's insights helped Laura to reevaluate her thesis research and turn it in a slightly different direction from employing scanning tunneling microscopy (STM) to utilizing laser Doppler vibrometry in her characterization of nanowires. Although their communication occurred mostly via phone and email, Howell was quite engaged in her progress, and he ultimately served on Biedermann's thesis committee. Laura's diversity of graduate school experience, particularly with STM, is now quite useful in her current work on a graphene LDRD project as a Sandia postdoc. She credits at least part of the reason for her diversity of expertise as stemming from the increased freedom she had in her doctoral research "to explore different projects." This flexibility, which accrued as part of the Sandia graduate research project, permitted her more of a hands-on focus with fewer distractions than she might have otherwise encountered in a more-traditional graduate school experience. Biedermann's graduate-work-derived publications are reflective of the expertise she acquired with graphene, the very expertise that is now a key asset to Sandia.

Moreover, as affirmed by Howell, Biedermann's interest in an ongoing relationship with Sandia markedly changed after visits to the Labs, during which she was greatly impressed by both the quality and diversity of Sandia's staff of its scientific and engineering research. This was far from a one-way relationship: "She started contributing right away," Howell emphasizes, particularly in areas such as STM and other techniques for optical trapping, approaches she was developing as part of her thesis research. During a visit to Sandia, Laura presented a seminar on her research, and Howell directly exposed her to his team's activities by bringing her to several project team meetings where



Scanning tunneling microscopy (STM) images of epitaxial graphene grown at 1500 °C on the carbon-face of SiC.

In (a), an STM image of a 5 x 5 nm^2 region shows broad SiC terraces covered by few-layer graphene. Fine graphene ridges, 5-10 nm high, cross the sample.

In (b), an STM scan of a 150 x 150 nm^2 region shows a moiré superlattice continuing across a 1.1-nm SiC step edge. A mis-rotation of the topmost graphene layer with respect to the underlying layer(s) results in a moiré superlattice. The moiré superlattice is atomically flat; the apparent enhanced corrugation is a density of states effect.

The graphene ridges in (a) form upon cooling due to the difference in thermal contraction between the basal plane of graphite and the SiC substrate. The ridge formation causes a relative rotation between graphene layers, resulting in the observed moiré superlattices, such as in (b).

she could intimately focus on the cooperative nature of his LDRD-funded research projects. "She started seeing how important this was, and how you can be proud and make a difference," Howell says, in projecting Biedermann's sophisticated ability to manipulate graphene layers as important to several potential applications for national security, from delicately accurate molecular sensors to the somewhat futuristic possibility of all-carbon circuitry.

"I hadn't considered a career at a national lab before I came to Sandia," Laura reflects. "Only electronics components for weapons are done here, I thought," she confesses her initial naiveté; "but the breadth of research. . . there are so many outstanding engineers, scientists and technologists . . . and the facilities are top-notch." By the time she reached the home stretch of her doctoral research, it had dawned on Laura that she was indeed seriously considering Sandia as a site for a postdoctoral experience, based on her newfound understanding of how much the Laboratories' spectrum of nanoscience research would resonate with her background and her own research interests. Her Sandia postdoc application successful, Laura immediately became a productive member of Howell's team, studying and effecting the deposition of high-quality, large-area graphene onto silicon carbide — and eventually silicon —substrates, to enable Sandia's progress as a competitive player in what may prove to be a novel generation of chip architectures. From Howell's perspective, he views Laura as a key component of "a great team," and sees himself as "pretty lucky" to have recruited her. "It's really fun leading a team like this," he comments; "we're getting nice results and having impacts." And with respect to his future participation in the graduate research program arena, he is unambiguous: "I hope I get a chance to do it again."

Presidential Early Career Awards for Scientists and Engineers

The PECASE embodies the high priority placed by the government on maintaining the leadership position of the United States in science by producing outstanding scientists and engineers and nurturing their continued development.

DOE/NNSA Defense Programs (DP) identifies nominees for the Presidential Early Career Awards for Scientists and Engineers (PECASE) from the most meritorious recipients of the DOE/NNSA-DP Early Career Scientist and Engineer Award. Candidates for this award are researchers employed by academic institutions who are in the first five years of their independent research careers. Individuals are nominated by directors of DP laboratories based on the candidate's contribution to the DP mission. Up to six winners are selected annually by the Office of Defense Programs from the nominations provided by the laboratory directors. Up to three of the winners of the DP Early Career Scientist and Engineer Award may also be designated annually by the laboratory directors as DP nominees for the PECASE. The nominating laboratory is responsible for funding the PECASE awardee for the next five years.

The PECASE embodies the high priority placed by the government on maintaining the leadership position of the United States in science by producing outstanding scientists and engineers and nurturing their continued development. The awards identify a cadre of outstanding scientists and engineers who will broadly advance science and the mission. Further, the awards foster innovative and far-reaching developments in science and technology, increase awareness of careers in science and engineering, give recognition to the scientific missions of participating agencies, enhance connections between fundamental research and national goals, and highlight the importance of science and technology for the nation's future.

The award is $250,000, given to the awardees through a $50,000 per year research contract funded through the Laboratory Directed Research and Development (LDRD) Program. This provides the awardee an opportunity to continue research in the area for which he/she was nominated and for Sandia to benefit from the results of the developments.

Call for nominations is typically May-July of each year. Selections are generally made in November of the following year.

To illustrate a cross-section of PECASE Award impacts, we report on two projects for which FY 2009 formed the closing year of funding, and a third whose initial year of funding occurred in FY 2009.

A Role Model for University Partnerships

Bill King, University of Illinois at Urbana-Champaign (UIUC)
Blake Simmons (Org. 8600), Sandia PI

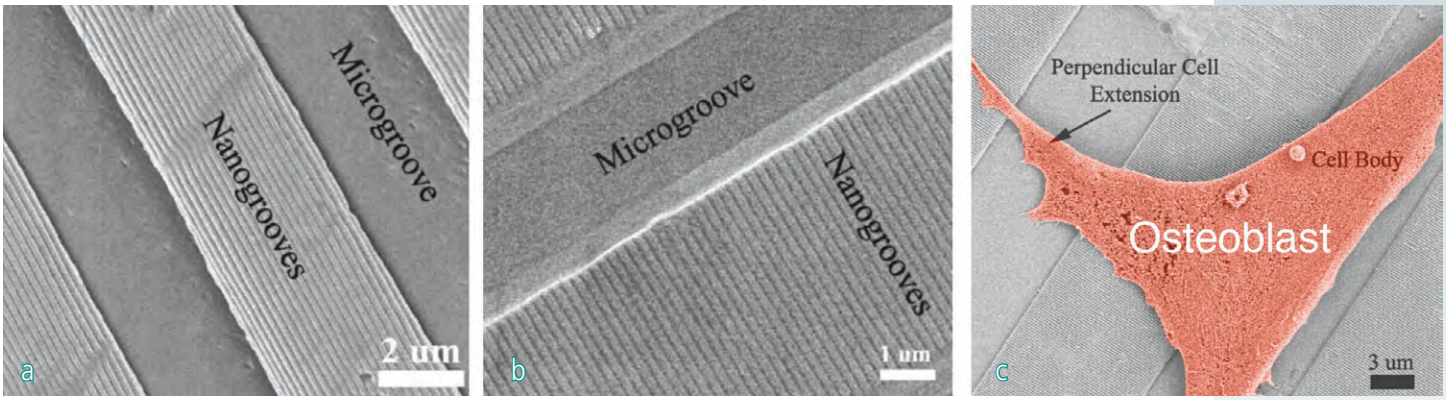
Both Sandia's Blake Simmons and UIUC's (formerly Georgia Tech's) Professor Bill King sensed a common ground when they first met at the 2001 Gordon Research Conferences. But their progress into a frank collaboration would require a catalyst, in this instance, Sandia then director and current Vice-President, Jill Hruby. Simmons recalls that Hruby recommended that he write a PECASE application for King. From King's perspective, Hruby's intervention was more of a prognostication. Introduced to her by a friend, King recalls Hruby telling him, "You're going to work with Blake, and it's going to be great." His recollection is that she delivered a similar pep talk to Simmons. In either case, reflecting on the outcome of his collaboration with Simmons, King is, in retrospect, amazed by Hruby's uncanny managerial abilities in perceiving productive symbioses. "She just knew it in some way . . . had such conviction; she had foresight — and was in a position to do something about it."

Prior to King's PECASE award, Simmons and King collaborated for several years, at one juncture funded by NNSA. The collaboration focused on polymer rheology (the dynamics of flow) at the nanoscale, the objective to gain a fundamental understanding of the phenomenon and its application to nanoimprint lithography ("stamping" minuscule patterns) with polymers. King was interested in connecting polymer science with engineering, by developing methods to imprint patterns in polymers of interest to different scientific disciplines.

For example, against the backdrop of an interdisciplinary center at Georgia Tech, some of the earlier work focused on biopolymers, materials relevant to bioengineers, who up to that point, were limited in their studies of cells explanted from animals into tissue culture by the fact that only glass and certain plastics were available as surfaces upon which to imprint patterns to direct the behavior of such cells. At the time, no one knew how to reliably imprint micro and nanoscale features into biopolymers or polymer composites resembling the complex assemblages of proteins and polysaccharides composing animal connective tissues like fascia or bone. King worked with osteoblasts, a type of bone cell responsible for forming new bone. Although not a biologist, he was broadly interested in the question of whether such patterns could be engineered and how nanoscale events (such as cellular movement and alterations in cell membrane composition) could be triggered by altering nanoscale topography. Studies such as these were part of the collaborative interaction with Simmons' work at Sandia, fundamental investigations that comprised part of DOE's mandate to advance the frontiers of nanoscience. In this case, understanding polymer rheology under conditions necessary to imprint nanoscale patterns would thereby broaden the possibilities

Bill King, UIUC

" . . . a role model for how university partnerships can work productively."



Scanning electron micrographs of patterns stamped into biopolymers (a and b), and showing the interaction of an osteoblast (bone-forming cell) with the patterned polymers (c). The cell has been colorized for convenience of viewing.

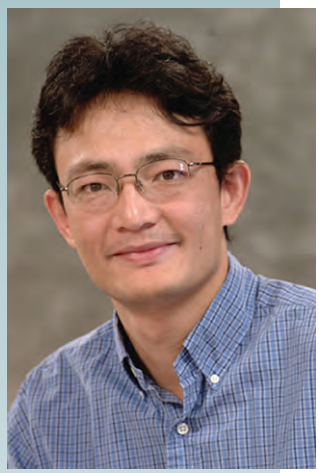
for the range of materials that could be called upon as substrates for nanoscale patterning for a variety of different applications.

Although King moved from Georgia Tech to UIUC, the PECASE award moved with him, and the research, a combination of modeling and experimentation, continued. "He's done marvelous work," Simmons comments; "he developed a toolkit — a rule book for how molecular weight, temperature, and pressure affect polymer behavior around nanoscale features." Three of King's graduate students became important components of the research, spending significant periods working at Sandia, and all three — Harry Rowland, Marcus Eliason, and Joseph Charest are co-authors on scholarly publications with Simmons, King, and another Sandian, Alec Talin. Rowland and Charest were recipients of the campus executive graduate research program as well. Indeed, according to King, Rowland is widely viewed as a —if not the — world expert on polymer rheology. Starting his own company directly after receiving his PhD, Rowland has received two rounds of venture capital funding and is working on implantable biocompatible devices. "The Sandia relationship made that happen," King maintains.

"PECASE gave me a chance to have so many connections to dozens of easy-to-find partnerships."

"PECASE gave me a chance to have so many connections to dozens of easy-to-find partnerships," King says, citing work with Sandians in nanoengineering, sensors, and other areas.

"Bill was a trail-blazer," Simmons says, reflecting on how important were King's insights to, for example, nanoelectronics work at Sandia. "I hold him up as a role model for how university partnerships can work productively."



Yunfeng Lu, UCLA

Transformative Research with Open-ended Impact

Yunfeng Lu, University of California at Los Angeles (UCLA)
Jeff Brinker (Org.1001), Sandia PI

"He's won just about every young investigator award," lauds Sandia Fellow Jeff Brinker in discussing his former graduate student and postdoc, the incredibly productive Dr. Yunfeng Lu, whom Brinker nominated for a PECASE award. As a young faculty member at Tulane University from 2001 to 2006, Lu rose to endowed full professor in three years, an almost unheard-of accomplishment, while he devised novel methods for manipulating nanostructures in concert with Brinker and Sandia's LDRD program.

" he got us going in that direction."

Lu's ability to use molecular self-assembly techniques at the nanoscale has been uncanny. During the PECASE research, he devised a method for aligning the pores in nanostructures perpendicularly to the substrate upon which he had grown a material, and according to Brinker, he was able to extend his methodologies to a range of materials, including conjugated polymer systems. Benefits of these accomplishments have accrued to Sandia, DOE, and DoD Defense Threat Reduction Agency (DTRA) over the past few years. For example, Brinker notes that Lu "got us going in that direction," in part referring to a current LDRD project in which Brinker's research group is building upon a combination of its own discoveries and Lu's work in synthesizing protein nanocapsules for purposes connected to novel delivery systems for drugs, detection systems for chemical warfare agents, and other applications. The uniqueness of Lu's research stems from a very thin (a few nanometers) polymer shell into which can be anchored biologically important proteins isolated from biological systems, so that the activity of the proteins — as enzymes, for example — is retained in this nonphysiological environment. This challenge of using the remarkable structural and functional diversity of bionanostructures removed from their normal cellular milieu has proven a daunting one for nanoscientists.

In turn, in a recent publication in *Nature Nanotechnology*, Lu credits Sandia for support

in addition to DTRA and National Science Foundation (NSF), from whom he received a Faculty Early Development CAREER Award. The interplay of research endeavor hence endures despite the fact that direct interaction is now largely on a personal level between Brinker and Lu, who communicate frequently.

But just as the impact of Lu's work continues on the research coming from Brinker's lab, the reciprocal effect is also in evidence, as Lu credits his experience during the PECASE period and also Brinker's recent work at Sandia and UNM for influencing the course of his own research. In 2006, Lu departed Tulane for UCLA and with the change in location also came a slight shift in the direction of his research. That research has since received DTRA funding, some of Lu's efforts turned toward homeland security, as his methods are amenable to devising detectors of chemical warfare agents, and antidotes for poisoning by such agents; in this sense, the Sandia connection is bringing distinct returns to the nation in Sandia-relevant mission areas. Moreover, Lu is working with other Sandians studying theoretical methods for further stabilizing the proteins in his nanocontainers, and if funded, will be part of a new LDRD on this topic.

The potential offshoots of the original Lu-Brinker collaboration and their respective subsequent research are poised to impact Sandia nanotechnology in other ways as well, opines Brinker. For example, although capable of producing intricate and interesting patterns at the nanoscale, self-assembly techniques are limited by the spatial expanse over which they are effective at forming unique nanostructures. However, by combining self-assembly, a "bottom-up" technique with a top-down directive technique such as lithography, Brinker has begun to demonstrate that self-assembly – engendered molecular patterns can be extended over chip-sized areas or larger — thus potentially leading to design of novel nanostructures for use in hybrid photovoltaics and separation/purification membranes, to name just a few possible applications.

A looming aspect to this collaboration is a planned initiative to reciprocally rotate graduate students through both laboratories to provide them with the broadest possible exposure to scientific ideas, discourse and techniques. With Lu's students coming to Albuquerque to work in Brinker's laboratory at UNM, they will undoubtedly be exposed to Sandia-funded work, as well as to other areas, particularly in nanoscience, such as through seminars and discussion groups in Basic Energy Science (BES) user facilities such as the Center for Integrated Nanotechnologies (CINT). In turn, Sandia stands to benefit from a potential source of postdoctoral researchers of the type of high-quality, highly motivated individuals whom Lu has been consistently able to attract to his laboratory.

Beginning with the intrinsically collaborative setting of Jeff Brinker's dual status as Sandian and UNM professor, and extending out to the utilization of PECASE awards to promote and/or continue academic collaborations, the remarkable early career and obvious future potential of Yunfeng Lu stands as a testament to the value for Sandia of LDRD-funded research in the context of university collaborations.

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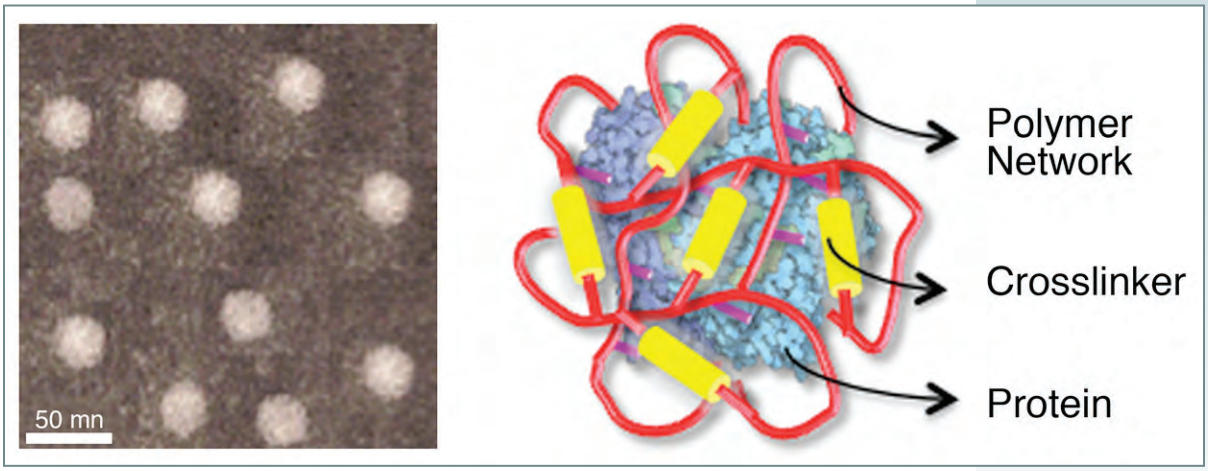


Transmission electron micrograph of 11 protein nanocapsules (light circles, left) and conceptual drawing of the components of a single nanocapsule (right)

SURP Spawns a Potentially Career-long Partnership

Jeanine Cook, New Mexico State University (NMSU)
Erik DeBenedictis (Org. 1422), Sandia PI

About seven years ago, Professor Jeanine Cook of NMSU submitted a successfully funded Sandia-University Research Program (SURP) proposal (see page 26) for a summary of SURP). At that point, it would have been difficult to predict the richness of the partnership.

Jeanine Cook, NMSU

"She is likely to be a friend of the Labs for the rest of her career."

Occupying a unique niche at NMSU, Cook's work entails building tools to aid in algorithm development, by modeling, at multiple scales, processor hardware, thus enabling increases in efficiency in predicting and facilitating the next generation of hardware architectures. In addition to contributing to DOE's advanced simulation and computing (ASC) initiative for nuclear weapons and other missions, these more powerful computational platforms are key to work in nanoscience and microsystems engineering and manufacturing. Cook was successful in her application for a follow-on SURP award, and by mid-decade, working with Sandian Erik DeBenedictis and others, that second award "really helped solidify the collaboration," she states.

Not only did Cook regularly travel to Sandia from Las Cruces, but DeBenedictis would likewise travel to NMSU to consult and give lectures to Cook's students. Gradually the interaction grew richer as Cook introduced several students to Sandia, who began to join DeBenedictis' group as summer interns. Ultimately, one of Cook's students was hired as Sandia staff.

"It feels like part of my job is to do this," Cook says, reflecting on one of her current students, "a really bright kid, who should get his PhD." She readily projects how a Sandia internship "will be really great for him, and good for Sandia."

From DeBenedictis' perspective, Cook's specific expertise brings a great advantage to Sandia. "Her particular talent in microarchitecture simulation" means that "her work is in greater depth than anyone else's." As computers become even more sophisticated, this type of simulation "will have to evolve, and Sandia will have to pick up at least some of that cutting-edge evolution from universities," DeBenedictis says.

That Jeanine Cook's research will comprise at least some of that cutting-edge work is clear from the fact that DeBenedictis led the charge on a Presidential Early Career Award for Scientists and Engineers (PECASE) nomination for Cook, recruiting recommendations from Sandians and students that resulted in Sandia's President and Laboratory Director's letter of nomination and a PECASE Award given by the Office of Science and Technology Policy on behalf of the White House.

Cook spent a year on sabbatical at Sandia. The logic was apparent in that the Sandia group of developers is one of the largest that does research similar to her own, placing Cook into an environment providing her with "the ability to work with a very broad spectrum of hardware and software developers." Integrating her models into the Sandia Software Toolkit (SST), she generated a model of the AMD (Advanced Micro Devices, Inc.) Opteron processor, commonly used in Sandia computers.

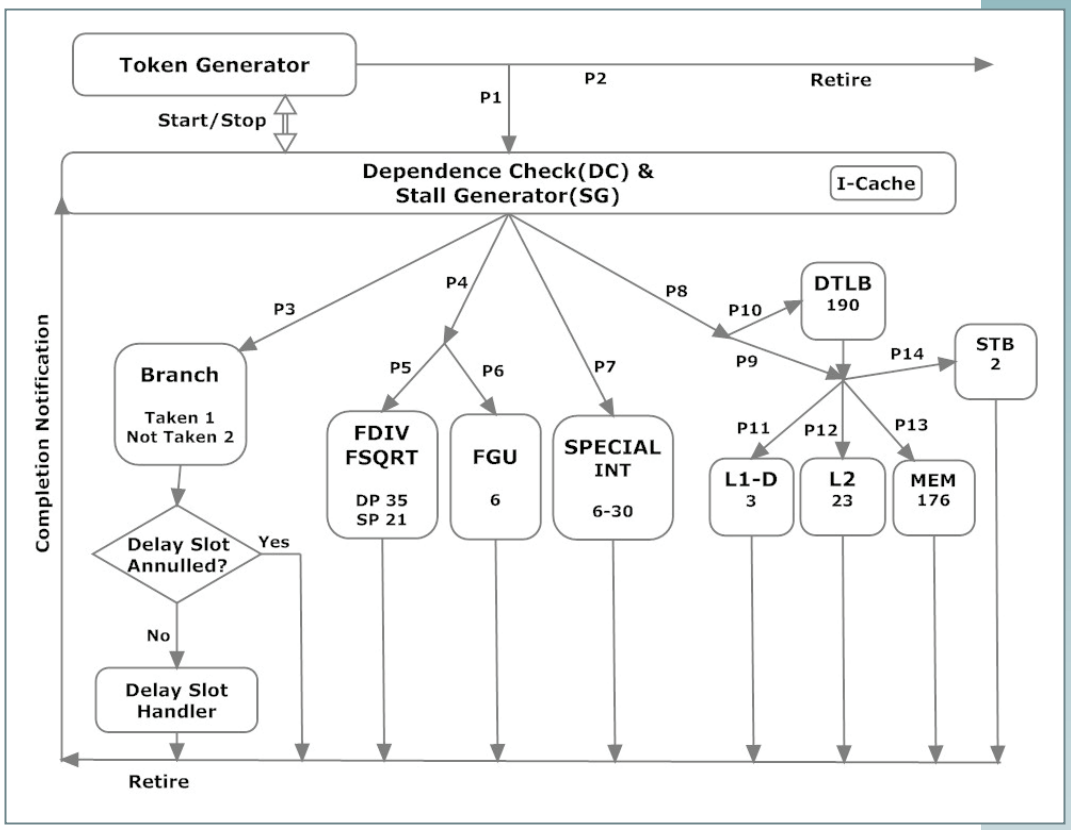
"Having me there, on sabbatical, strengthened the relationship," Cook states, her preference for face-to-face interaction an obvious one. One of the most positive outcomes from her vantage is securing Sandia help in developing her NMSU sub-curriculum in processor modeling, one which she admits is difficult for her to accomplish solo at the university. This Fall, Sandian Richard Murphy has agreed to teach a telecourse to NMSU students, supplementing that remote instruction with monthly visits to the campus.

Even more remarkable is the unanimity of agreement on the longevity of Cook's relationship with Sandia. "We're approaching questions that haven't been answered . . . that I don't see in the literature," she offers.

Nonetheless, she is a realist: "I confess there's long way to go, but it's pretty amazing. This is just the beginning," she adds. "This will be long-term."

DeBenedictis agrees, noting that as Sandia joins Los Alamos and Oak Ridge in progressing into the petascale realm of supercomputing, that continuous changes will be necessary to support this increase in processing power, and just as "SURP transitioned to PECASE and PECASE to LDRD, she [Cook] is likely to be a friend of the Labs for the rest of her career."

"None of this would've ever happened without SURP," Cook reflects.



Schematic of the simulation of the Sun Niagara 2™ processor.

Sandia-University Research Program (SURP)

Investment in new faculty development helps create partnerships that build long-term strength in areas deemed critical...

Since 1958, Sandia National Laboratories provided research-funding support to beginning faculty researchers at the University of New Mexico (UNM), the New Mexico Institute of Mining and Technology (NMT), and New Mexico State University (NMSU) through the Sandia-University Research Program (SURP). Each university researcher was partnered with a Sandia collaborator to satisfy the program's primary goals of obtaining needed scientific knowledge and technical expertise while strengthening the university-laboratory technical community in mission-relevant areas. Investment in new faculty development helps create partnerships that build long-term strength in areas deemed critical to support Sandia's Nuclear Weapons mission and its Science and Technology Research Foundations.

During FY2008, a decision was made by the Nuclear Weapons Sandia Management Unit (NWSMU) to scale down the program to consider second-year continuation proposals only for FY2009, and to discontinue the program altogether in FY2010 and beyond. These decisions were made due to decreases in NW program funding. Individual researchers continue to collaborate and invest in research projects with these universities.

Funding for SURP was from the U.S. Department of Energy/National Nuclear Security Administration's Office of Defense Programs through Sandia's NWSMU. This program was part of the Nuclear Weapons Readiness in Technical Base and Facilities People Readiness workforce development portfolio. In order to ensure a close association between the faculty member and the Sandia technical collaborator, the SURP program had a matching-funds requirement for each funded research project. The Sandia collaborators viewed these investments as excellent leverage for their program's research dollars. A new award was $40,000 per project, with $15,000 coming from the Sandia collaborator.

The SURP projects were selected for their high relevance to Sandia's research interests and mission needs. The project complemented Sandia's Nuclear Weapons Capabilities as well as its Research Foundations, which include materials and process sciences, computational and information sciences, microelectronics and photonics, engineering, and pulsed power. Projects may also include maturation and/or commercialization research support of technologies under development at Sandia. SURP benefits to Sandia include increased understanding in the subject matter explored by the projects, exposure to unique research areas, cost-effective research, and collaborative relationships between Sandia and New Mexico university faculty.

Universities and individual faculty members benefit from their participation in SURP through increased interaction with Sandia researchers, increases in faculty research production, faculty and student recruitment, grants from other institutions, experience in managing projects and student assistants, and awards, tenure, and fellowships.

The Sandia-University Research Program (SURP) funded five collaborative research projects with faculty at two New Mexico universities in FY 2009. FY 2009 marked the program's final year.

Teaming for More-efficient Modeling

Curtis Storlie, University of New Mexico (UNM)
Laura Swiler (Org. 1411), Sandia PI

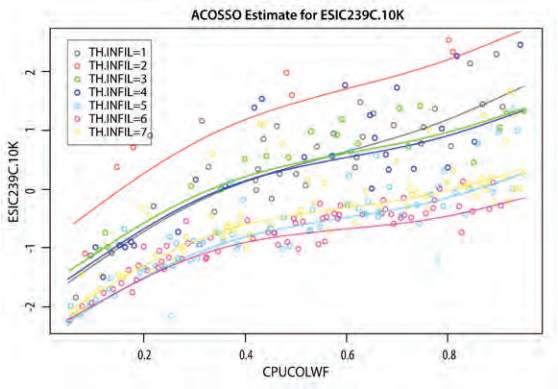
Because of a prior software development connection with Sandia through Jon Helton, newly hired UNM professor, Curt Storlie recognized that the SURP program would be "a really good way to get more involved . . . produce more quality work." At the Sandia end, mathematician Laura Swiler, a long-time Helton collaborator, was consulted by Helton about what possibilities might exist for bringing "a very bright young UNM faculty member" into a closer working relationship with Sandia. Informed of the program by his department chair, Storlie seized on the opportunity to apply for a SURP project.

Swiler's work had been focused on Gaussian process models, probabilistic, non-parametric regression models for nonlinear dynamical systems, which are a focus of many different physical and engineering phenomena studied by Sandia. Problematically, the complexity of such models, with their sometimes hundreds of input variables — whose values are often imprecisely known — makes them quite computationally expensive to run. Curt Storlie had developed a library of meta-models, surrogates that could allow modelers to "get a handle on uncertainty," by estimating a particular variable's importance in producing uncertainty in the model's output. In this methodology, termed "sensitivity analysis," the goal is to identify the most significant variables affecting the output results of a model.

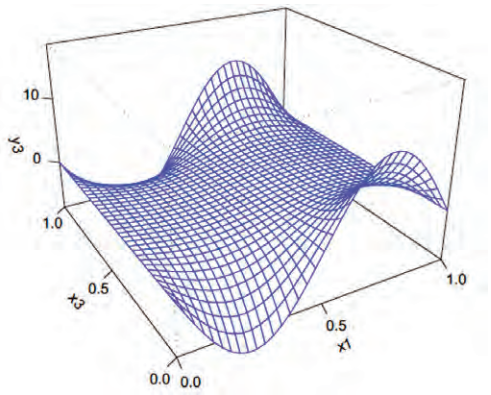
"I would have been working on sensitivity analysis, regardless, but this collaboration really helped to tie the methodology to practical issues," Storlie says. And while, from his perspective, the SURP funding allowed him to ground his work in real-world applications, from Laura Swiler's perspective, Sandia benefitted greatly in its modeling studies around Yucca Mountain and WIPP (Waste Isolation Pilot Plant), using Storlie's meta-models to reduce the number of variables, thereby making the models more efficient and less computationally expensive.

Additionally, benefit accrued to the statistics program students at UNM in the form of *STAT 579: Analysis of Computational Models*, a Spring semester 2010 course taught by the team of Storlie, Swiler, Helton, and Sandian Cedric Sallaberry, the same team that coauthored a paper appearing in the May 2009 issue of the journal, *Reliability Engineering and System Safety* (with another paper in preparation). "SURP facilitated this collaboration," Swiler observes, echoed by Storlie who feels that "it was extremely valuable for me," and that "Sandia will benefit from this, going forward." Part of that forward progression entails Storlie's move from UNM to Los Alamos National Laboratory (LANL), which he describes as "an extremely difficult decision," when weighed against an offer from Sandia. The good news, however, is that the collaboration will continue,

Storlie recognized that the SURP program would be "a really good way to get more involved…produce more quality work."



Plot of the Output versus the two most important inputs with the fitted meta-model for the Yucca Mountain study.



A plot weighting the importance of inputs x_1 and x_3 against an output, y_3.

not simply because as Storlie paints it, "it's important for the labs to share information," but also because of DOE's NEAMS Program (Nuclear Energy Advanced Modeling and Simulation), a key component of modeling the physics of next-generation nuclear reactors, which are a crucial component of the nation's energy security. Swiler is already working with LANL as part of the NEAMS consortium, and so Storlie's entry will undoubtedly enrich the extant collaboration, which in terms of national security is surely among the most important initiatives.

"students... will likely come back to Sandia"

Storlie also projects positive outcomes from *STAT 579*, believing that "students are getting practical information that will likely come back to Sandia in the probability that some of them will work there." In addition to the already productive research and the likelihood of more of the same in the NEAMS Program, such an outcome would represent compounded interest on the SURP investment.

Virtual Reality, New Mexico Style

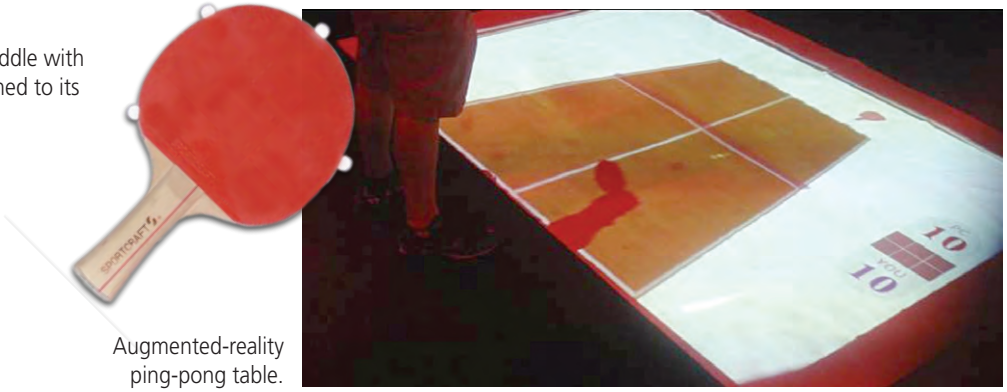
Pradeep Sen, University of New Mexico (UNM)
Carl Diegert (Org. 1412), Dan Small (Org. 6473), Eric Parker (Org. 6345), Sandia PI

"better human intuition to understand complex data sets."

An initial perusal of UNM Professor Pradeep Sen's research progress report might induce one to believe that this work was emanating from a Los Angeles startup virtual reality company. But according to Carl Diegert, one of Dr. Sen's Sandia collaborators, Pradeep is doing "high-value" work that Sandia has not had the time or resources to pursue, but whose value to the Laboratories lies in its unique ability to bring "better human intuition to understand complex data sets."

Pradeep Sen chose to pursue an academic career at UNM after receiving his doctorate from Stanford, largely because he saw the computer engineering department and its media program as "fast-growing but not having reached a critical mass." Comparing the situation to Microsoft in the 1980s, he saw an opportunity to join a sort of startup and "be part of the growth." The presence of a national laboratory like Sandia also influenced that decision, given Sen's recognition of the possibilities for collaboration. From Sandia's end, Diegert played a role in encouraging Sen's decision and in apprising him of SURP.

Pradeep Sen's view of the SURP funding is quite lucid, it's value characterized as a "launch-pad." "It allowed me to get up on my feet; helped me stabilize the situation until my lab could grow." In helping him establish his research, it also allowed him to collaborate with Sandia on several levels. First, his most direct contribution is in the area of computational engineering research in intelligent systems control, including the potential for much better intuitive visualization of physical and biological complex systems, as Diegert frames it, "coaxing more out of our computers." Sen's augmented-reality engine, implemented in the Art, Research, Technology and Science Laboratory (ARTS) at UNM allows users to visualize and interact with complex



Ping-pong paddle with sensors attached to its outer rim.

Augmented-reality ping-pong table.

data in an intuitive way. An every-day example incorporating physics simulations might be a virtual ping-pong game, in which users employ real paddles (ping-pong racquets) equipped with lightweight sensors to hit a virtual ball back and forth. The sensors track each paddle's motion in the real world, relaying that information to computational algorithms that translate it into motion in the virtual world, so that the user's interface with the virtual ball and table is seamless.

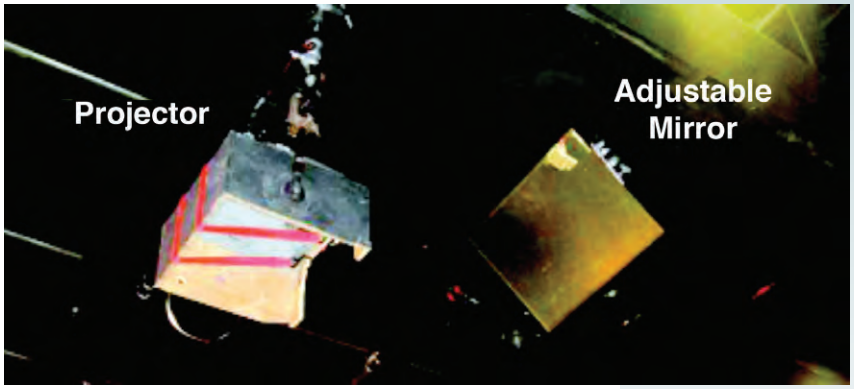
But there is also physics encompassed in the motion of the ping-pong paddles and the way they apply force and convey angular momentum (spin) to the ball. These algorithms are processing some quite complex information (data sets), rapidly enough such that the virtual ball immediately behaves in an appropriate real-world fashion, traveling across the table with a velocity and spin appropriate to the actual racket swing in real space. Such rapid computation with intuitive human feedback can be invaluable in physics problems important to Sandia. For example, Diegert poses an interactive virtual reality scenario in which engineers, who have conducted numerical simulations, are able to watch the airflow currents around the body of a vehicle (car or airplane), in such an interactive virtual reality format, to better understand on an intuitive level the reasons a vehicle might be losing gas mileage. Diegert maintains that when bringing together a collection of diverse scientists and engineers of different areas of expertise, "it's likely that the collaboration will be more successful if the entire group can better understand the problem." Such joint intuitive appreciation of a problem frames one of the reasons Diegert believes that Sen's building this core capability at UNM is so valuable to Sandia, giving the Laboratories access to theory and practice that to develop internally would require an enormous commitment of resources.

"It's like having another laboratory pulling in the same direction," as Diegert frames it. And this has ancillary benefits, such as the fact that vendors supporting this type of virtual-reality infrastructure can place a single technician to serve both UNM and Sandia, keeping both updated on new developments in technology. At a time when the center of this arena is the movie industry in Los Angeles, to have Sen's laboratory — as well as New Mexico's burgeoning film-production industry — close at hand is a triple win-win-win, for UNM, Sandia, and the state. "Together we can bring people in to be on the map in that area," Diegert concludes.

Indeed, Pradeep Sen is clearly helping to put UNM and Albuquerque on the map, attracting speakers and top students, reflecting Sen's desire to see the "exciting" outcome of "bringing a critical mass of people here." Already this outcome has directly benefitted Sandia in the arena of staff recruitment. Finishing his Masters degree in Sen's lab, Jon Bradley has been hired by Sandia as a staff member, working under manager Mike Skroch of Interactive Systems Simulation and Analysis (Org. 6385), and also with Dan Small of Intelligent Systems Controls (Org. 6473) who characterizes Bradley as "working out fabulously." Small also comments on the "very bright" individuals whom Pradeep Sen tends to attract, and that he expects will continue to provide a pipeline for highly qualified Sandia staff. Meanwhile Skroch comments on possible Defense Advanced Research Projects Agency (DARPA) interest in Sen's work in the area of information assurance concepts.

In short, it will clearly behoove Sandia to sustain and nurture this collaboration, initiated through a SURP project. Although Sen has recently secured a $600K NSF Young Investigator grant, with partners including Sandia, Los Alamos, and the Indian American Institute for the Arts, funding is always an issue and he is searching for opportunities for additional support. His success would represent a win for all involved parties.

The sensors track each paddle's motion in the real world, relaying that information to computational algorithms that translate it into motion in the virtual world. . .



Virtual reality projector and mirror within the UNM ARTS Lab.

A Nanoscience Network

Zayd Leseman, University of New Mexico (UNM)
John P. Sullivan (Org. 1132), Sandia PI

"lots of collaborative opportunities . . . into which to funnel his students"

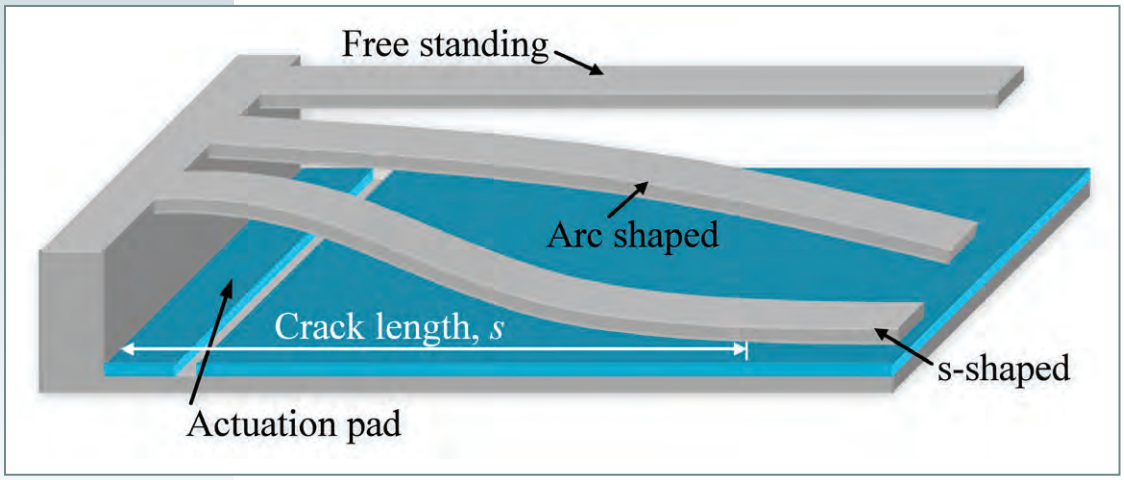
How does an engineer rectify stiction failure within a closed, packaged microsystem (more specifically, a microelectromechanical [MEMS] system)? A collaboration at CINT (the Center for Integrated Nanotechnologies) between Sandian John Sullivan and UNM professor Zayd Leseman has gone a long way toward answering that question.

Leseman was finishing his PhD research at the University of Illinois at Urbana Champaign (UIUC), when he and Sullivan met at a scientific conference, and Sullivan had already developed "lots of regard for his MEMS work." Given the mutually perceived overlap in their research interests, they discussed the possibility of a Sandia postdoc position, but in the interim, Leseman received the offer of an assistant professorship from UNM. Although in terms of endowment size, UNM was "not MIT or UIUC," Leseman recognized a nanoscience program on the upswing and "the proximity of Sandia and Los Alamos was a very positive selling point"; Leseman accepted the faculty position.

"It was great news for me . . . made it easier to collaborate," Sullivan comments about the turn of events. That ongoing mutual interest in collaborating led to Leseman's funded SURP application. "SURP was a great jump-start for a new faculty member, a really nice asset for some short-timeline funding, allowing him to bring in some graduate students," Sullivan observes.

The collaboration's fit was a quite productive one. Amid a significant theoretical and modeling environment at CINT, Leseman brought the experimental skills of a mechanical engineer to the micro and nanomechanical arenas of microelectromechanical system (MEMS) devices, microscale assemblages of minuscule moving parts and electronics at chip-scale size, which are often used a tiny sensors both in homeland security and medical applications. Frequently, components of such MEMS devices are microcantilevers, somewhat analogous to microscopic diving boards that oscillate with known properties. When a diver steps onto a full-sized board, its movements, of course, change, and microcantilevers are analogous in that their motion changes when molecules of particular substances adhere to them, substances for which they can be specialized to bind, and therefore can recognize as sensors. The changes in microcantilever movement will be a function of the amount of binding of a given substance (reflecting that substance's concentration), and integrated microscale or nanoscale electronics will send a signal about the concentration of that substance in the MEMS device's environment — glucose in a diabetic patient's blood, for example.

Problematically, microcantilevers can suffer from a phenomenon known as stiction, a type of microscale adhesion that inactivates their function, and which Sullivan characterized as a "constant MEMS issue." This might be especially relevant for a packaged sensor that has been stored for a time prior to use. Leseman's work at CINT approached a solution to this problem through the use of alternating



Conceptual drawing of free-standing (functional) microcantilever (top), arc-shaped stiction-failed microcantilever (middle), and S-shaped stiction-failed microcantilever (bottom)

current electric fields to free a microcantilever frozen by stiction, a method that can be used in an intact, already packaged MEMS device, thereby avoiding the pitfalls of potentially expensive and destructive disassembly/reassembly.

"This was an ideal opportunity for Zayd to collaborate, in terms of the capabilities in my lab," Sullivan notes. Leseman and his graduate student, Drew Goettler, a former Air Force captain, formally became users at CINT, and two papers including Goettler, Leseman, and Sullivan as authors are in the pipeline for publication. The stiction work funded by SURP directly led to Goettler's MS from UNM. Additionally, it has resulted in funding to Leseman through an NSF grant that includes Sullivan and CINT as collaborators.

Moreover, the collaboration not only continues but has broadened. Goettler is pursuing his PhD, his research closely connected to a current LDRD project headed by Sandian Ihab El-kady in the area of phononics. Leseman is likewise a contributor to this project, but he has also collaborated or is currently collaborating with numerous other Sandians, including Troy Olsson (1749-2), Matthew Blain (1725), and Eric Shaner (1128). "A marriage made in heaven," Leseman effuses, on the one hand, referring to engineering manpower available to Sandia by way of many quality graduate students flocking to UNM's nanoscience program, and on the other to "intellectual stimulation" that exposure to Sandia science brings to UNM personnel, in return. According to Sullivan, Leseman will find "lots of collaborative opportunities at Sandia" into which to "funnel his students."

From Leseman's perspective, proximity is a genuine virtue. He notes that professors are loathe to send their graduate student away to work in other laboratories because it cuts down on direct contact time and potentially interferes with other responsibilities of their graduate program. But that issue is made far more tractable with the geographic proximity of UNM and Sandia. And with a greater number of UNM graduate students coming to do work at Sandia should ensue a greater likelihood that some will be identified and successfully recruited as staff members. Leseman's feedback around Drew Goettler is that his Sandia investigators are "ecstatic" about his work, and indeed, Goettler is likely to be first in the recruitment line as he finishes his doctorate.

Throughout this productive, collaborative atmosphere, Leseman has only one regret. "I feel sorry for new junior faculty coming in . . . because of the SURP ending."

...with a greater number of UNM graduate students coming to do work at Sandia should ensue a greater likelihood that some will be identified and successfully recruited as staff members.

Modeling a Framework

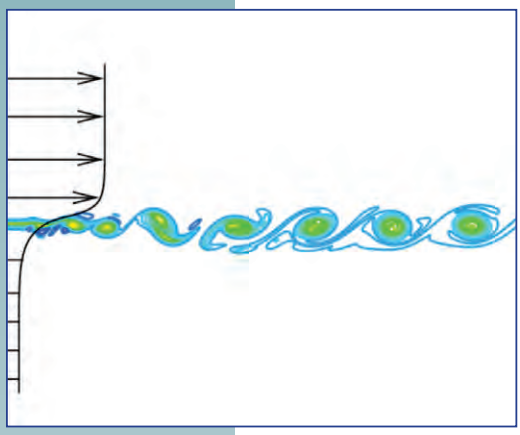
Mingjun Wei, New Mexico State University (NMSU)
Matt Barone (Org. 6333), Bart van Bloemen Waanders (Org. 1414), Sandia PI

One of the necessities associated with conducting research in a given scientific discipline is maintaining a critical awareness of the research of other scientists in the discipline, in terms of how that research may inform and complement one's own endeavors. Such was the case for Sandia's Matt Barone, who as an engineer interested in models of aeronautical airflow and turbulence, had followed the work of his graduate school contemporary, Mingjun Wei. Wei had done research in modeling of such flows, and when he became a faculty member at NMSU, Basil Hassan, project manager on Matt's LDRD project suggested that a SURP award might be a useful vehicle for collaboration, given the overlap in interests.

The collaboration seemed quite logical, with Barone doing theoretical work, but ultimately interested in its applicability to engineering phenomena in both aircraft wings and wind turbine blades. Wei was developing so-called reduced-order models, which essentially draw from complex, computationally expensive simulations in an attempt to develop numerically simpler and less expensive models that will nonetheless yield reliable results of utility to engineers studying these issues as physical phenomena —problems in engineering optimization. The collaboration also extended to Sandian Bart van Bloemen Waanders, a computer scientist whose work included the development and use of reduced-order models.

"It's a framework for establishing future collaborations."

"SURP provides a really nice opportunity to connect academia with Sandia researchers," van Bloemen Waanders comments, and in this instance it was clear that a fruitful connection did ensue, not only among Wei and the two Sandians but in the fact that Barone and van Bloemen Waanders became more familiar with each other's work; they subsequently co-developed an LDRD idea. The three scientists published a conference paper together at the 47th American Institute of Aeronautics and Astronautics (AIAA) Aerospace Sciences Meeting, and funding supported a graduate student in Wei's laboratory at NMSU.



It appears that the SURP funding was not completely adequate to support the type of time investment that the three researchers would have been interested in investing. Hence, Barone and Wei are on the lookout for a funding proposal that might provide the necessary support. Barone and van Bloemen Waanders traveled to NMSU to offer a seminar on reduced-order modeling, and they feel that the combined initiatives have strengthened ties with NMSU's engineering department. "It's a framework for establishing future collaborations," Barone believes.

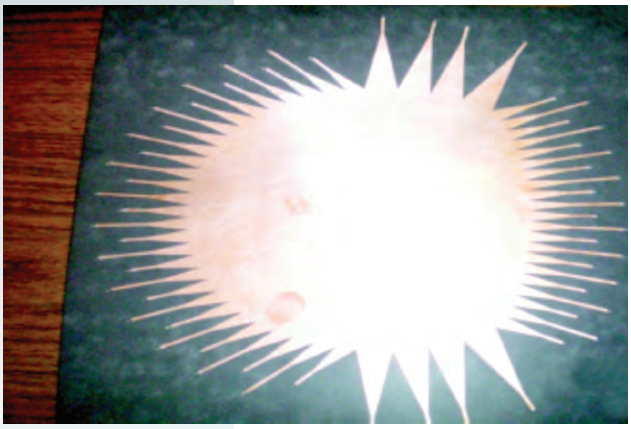
Left: Schematic of a spatially developing free shear layer

A Fruitful Project with Future Potential

Muhammad Dawood, New Mexico State University (NMSU)
Lee Marshall (Org. 2666), Sandia PI

"This could be phenomenally beneficial to Sandia because of the relationships."

This project's goal was to develop a very small, low-loss, multidirectional, multi-beam antenna system, and it brought a one-dimensional prototype to fruition, with a team at NMSU still pursuing a two-dimensional version. The engineering encompassed in such an endeavor was originally directed at an external customer; however, the project turned into more of a demonstration of possibility when that situation unexpectedly changed. This did not deter NMSU's Professor Muhammad Dawood from pursuit of the challenge. A native of Pakistan, who saved for 10 years to come to the US (University of Nebraska) for graduate study in ultra wideband radar and sensing systems, Dawood arrived at NMSU after research experiences at the University of Kansas, and he relishes his role as student mentor, and as an individual who helps train his students for engineering careers.



Learning about the SURP Program through a direct visit to NMSU by Sandia University Research Office staff, Dawood initiated the project with Sandian John Moser who handed it off to Sandian Lee Marshall after he changed organizations. Marshall believes that the NMSU work has shown that the multi-beam antenna system technology is possible and applicable to a problem set to which Sandia has been pursuing a solution. For the present, the work remains latent, but Marshall sees its potential to be reactivated and fully realized should the need arise.

Meanwhile, Dawood has been able to support graduate students through department resources, at least one of whom he believes

Rotman lens, a key optical component utilized in approaching a solution to engineering a multi-directional, multi-beam antenna system in this project

would make a great addition to the Sandia workforce, a student who has indicated interest in that direction. In turn, Marshall believes that "the capabilities and knowledge that students would have . . . would fit well with several Sandia groups. This could be phenomenally beneficial to Sandia because of the relationships that are built," Marshall observes. Dawood is, in turn, grateful to Sandia for what he perceives as a "badly needed incentive" for graduate student exposure to an actual engineering effort relevant to Sandia's mission.

Dawood continues his pursuit of a closer research relationship between Sandia and NMSU, always with a mind toward funneling students into a potential career path as Sandia engineers. Marshall, in principal, agrees; he sincerely believes that university research collaborations, developed to build strong relationships, are genuinely important for both Sandia and the collaborating university.

UNIVERSITY OF TEXAS SYSTEM

Their overarching goal is to achieve a greater mutual impact on national security issues.

The University Partnerships Office supports interactions with some universities that do not have "campus executive" status. Such interactions are meant to explore niche technical areas of interest and forge new strategic relationships in critical skills areas. These programs are evaluated regularly to determine their value toward achievement of Sandia's mission objectives.

Sandia and the University of Texas System (UTS) signed a joint Memorandum of Understanding, charging their institutions with strengthening Research Program Interfaces and Collaborations, Peer Review and Scientific Accountability, and Education and Transformation. Their overarching goal is to achieve a greater mutual impact on national security issues. Its strategic purpose is to participate with Sandia scientists on collaborative research projects, to provide peer review for Sandia's research programs, and to provide specialized courses taught by UT professors to increase educational opportunities for Sandians.

Research program interfaces and collaborations currently exist in the areas of bioscience and biodefense through collaborations with UT Medical Branch in Galveston and the MD Anderson Cancer Center in Houston; through the National Institute for Nanoengineering (NINE), the National Initiative for Modeling and Simulation (NIMS), the Center for Advanced Reconnaissance and Remote Sensing (CFARRS) and through the Institute for High Energy Density Science (IHEDS).

UTS is providing independent oversight to assess and enhance Sandia's Science, Technology and Engineering excellence through the Peer Review process. At the request of the Science and Technology Subcommittee of the Missions Committee of the Sandia Board of Directors, the UTS Vice Chancellor for Research and Technology Transfer assumed responsibility for decisions associated with the membership of the six Research Foundation External Review Panels (ERPs). Chairs of each ERP also serve as members of the Sandia Science Advisory Board (SSAB). Working in concert with the Sandia Chief Technology Officer, formal, independent UTS oversight of the panel vetting process continues to provide integrity to the external advisory and review process.

The partnership in Education has directly benefited Sandians. The Texas State legislature, in 2005, granted the UT System permission to charge in-state tuition and fees to employees and dependents of organizations working with UT in science and technology development. Sandians and their dependents can pay in-state rates when enrolled at a University of Texas System institution. This benefit also extends to those taking distance-learning classes.

Overall, in FY09, Sandia had research contracts totaling $1.7 million with UT Austin, UT El Paso, UT Arlington, and UT Medical Branch. There were no contracts placed with UT-Dallas, or Southwestern Medical Center. Approximately 191 UT System graduates are currently employed at Sandia, compared to 192 in FY08. In addition, 14 students from the UT System currently work for Sandia, up from 9 in FY08.

Two partnerships, the Sandia-UT Austin collaboration in NIMS (National Initiative for Modeling and Simulation) and the biomedical collaboration between Sandia and the University of Texas Medical Branch (UTMB) at Galveston are highlighted here. Both partnerships display a triad of benefits — in actual research conducted, in the successful procurement of external funding, and in the fruitful sharing and/or exchange of teaching and research personnel.

Completing the Trinity

National Initiative for Modeling and Simulation
Art Ratzel (Org. 1500), Sandia Lead

Theory, experimental testing, and computational modeling/prediction: such is the trinity of approaches that are coalescing under the aegis of NIMS, the National Initiative for Modeling and Simulation, a collaboration between Sandia and the University of Texas-Austin (UT). With its roots in both UT's (initially) privately endowed Institute for Computational and Engineering Sciences (ICES) and extant UT-Sandia collaborations, NIMS represents an attempt to define several grand challenge areas in national and global security.

Occupying its own building on the Austin campus, the 10-year-old ICES is a truly multidisciplinary institute, encompassing 11 research centers composed of 87 affiliated faculty from 11 different academic departments, and led by renowned materials scientist, mathematician, and engineer, J. Tinsley Oden. In late 2007, Oden with input from his faculty, conceptualized NIMS in a white paper as a much larger vision, a way to expand the mission of ICES beyond simply the UT System—as an interdisciplinary partnership among universities, national laboratories, and beyond.

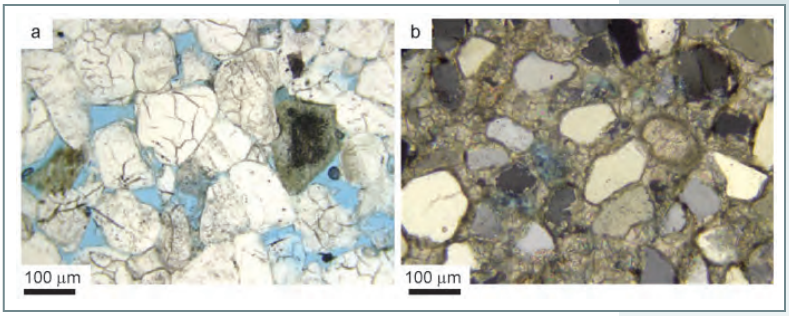
"We've been blessed that he's accepted us as a partner," says Art Ratzel, the Sandia lead in the NIMS partnership. From the UT Chancellor's office through Sandia Laboratory Director, Tom Hunter, to then Chief Technology Officer, Rick Stulen, the NIMS model received unanimous approval, and startup funding from both institutions, some of Sandia's coming through the Strategic Partnerships Investment Area of the LDRD program. Although the overall mission of NIMS was to elevate computational modeling and predictive simulation to the most sophisticated possible level, there came a great diversity of potential focus areas from the broad range of extant ICES faculty, with ideas ranging from modeling the human cardiovascular system to simulating the behavior of quantum systems.

Ultimately, this trove of ideas was condensed to three Grand Challenge (LDRD) arenas that were crucial to national security, free of classification issues, reasonably encompassing of many of the submitted ideas, and focused on areas in which strengths were already in existence at both UT and Sandia. Moreover, the NIMS model goes beyond simply research to the teaching aspect of training the next generation of both graduate students and postdocs in the multidisciplinary fashion that will be required of the next generation of researchers.

"It's about changing the way we do science and engineering."

The first Grand Challenge area is Computational Modeling of Geosystems, more specifically, science and engineering modeling for carbon dioxide (CO_2) sequestration. Implications of this modeling effort impact the critical mission areas of both climate change and energy security. To successfully assist in enabling meaningful sequestration of CO_2 would both reduce atmospheric concentrations of this greenhouse gas and would likely extend the useful life of resources such as natural gas, permitting a more gradual transitioning of energy economies from fossil fuel combustion to more carbon-neutral energy sources such as wind and solar. This UT-Sandia collaboration has received funding as a DOE EFRC (Energy Frontier Research Center) in the amount of $15.5M over five years, its specific collaboration entitled, *Center for Frontiers of Subsurface Energy Security* (CFSES).

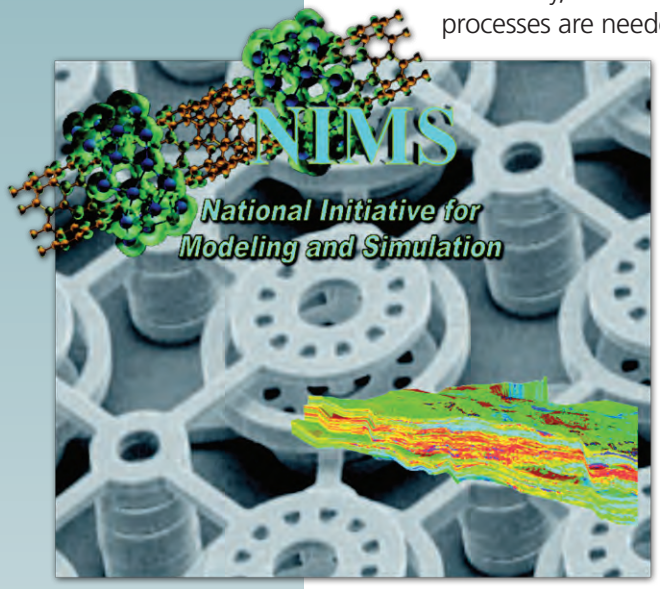
The second Grand Challenge area, that of Advanced Computational Materials, studies the design of nanostructured materials for the information and energy sciences, such as those semiconductor materials utilized in solid state lighting, photovoltaics, and other materials in which electrical charge separation and transfer is key to functionality. This initiative has also received its own DOE EFRC funding in the amount of $15M over five years. Computational modeling in this thrust area naturally partners and integrates with the research and teaching activities of Sandia's National Institute for Nanotechnology (NINE), particularly around Sandia's strength with experimental



Sandstone pores unaltered (a) and altered (b) by exposure to CO_2

characterization of light-emitting diodes (LEDs) and photovoltaic materials.

The third Grand Challenge area is that of Computational Modeling of Nano-manufacturing, an initiative that Ratzel characterizes as setting the stage for the "next generation of computationally designed nano-parts." In other words, this initiative prepares the way for large-scale, high-throughput production of nanostructured materials, for which markets are projected to exceed $1 trillion by 2015. Nanomanufacturing is still in its infancy, and computationally designed processes are needed to ensure accurate, high-volume manufacturing at high speeds, over large areas (batch operation) with feature sizes less than 100 nm. NIMS is currently competing for National Science Foundation (NSF) funding as an Engineering Research Center (ERC) for Computationally Engineered Nanomanufacturing Processes.



NIMS "emblem"

In addition to the continual efforts to secure endowment funding, NIMS also continues to build collaborative ties by supporting student exchange, particularly through graduate student research projects, as well as through faculty sabbaticals by which researchers can actively spend time doing research across the partnership institutions. There is an ongoing effort to expand that institutional scope, by recruiting other universities, federal laboratories, and even corporate participation into the partnership. "The time is right," emphasizes Ratzel, in his belief that the computational initiatives at NIMS can support and facilitate the work of NINE, as well as of other UT-Sandia partnerships, such as the Joint Institute for Biodefense Technical Acceleration and Commercialization (JIBTAC) collaboration between Sandia and the University of Texas Medical Branch (UTMB) (see following article). "The sky's the limit," Ratzel believes, in terms of ultimately securing collaborative commitments from other universities, national laboratories, and corporations.

Finally, there is the obvious staff pipeline potential, and this has and will likely continue to play a large role in defining the benefits of the NIMS partnership to Sandia. UT faculty have come to Sandia to present coursework, and according to Ratzel, Sandia has hired "a ton of his [Oden's] students, over the years." There is a firm belief that both these individuals and the entire culture of NIMS indeed defines the future — "it's about changing the way we do science and engineering."

A New Generation of Bioscientist

University of Texas Medical Branch

Glenn Kubiak (Org. 8600), Sandia Lead; Anup Singh (Org. 8621), former MISL PI

"a vision that galvanizes"

When adequately recognized and given credence, complementary capabilities and strengths can form the cornerstone of a great partnership. With some nurturing through communication and accomplishment, such a partnership can develop broader vision. Such is the case for the collaboration between Sandia and the University of Texas Medical Branch (UTMB), Galveston, which in a brief six-year time span, has spawned a vision broader and more impactful than its originators might have initially conceived — a vision for a very long-term impact on national security through biodefense and infectious disease mitigation.

As Sandia investments in biosciences deepened at mid-decade, particularly with the submission of the MISL (Microscale Immune Studies Laboratory) LDRD Grand Challenge proposal in 2005 (funded FY 2006 through FY 2008), Sandia recognized the desirability of a strategic biodefense partner. In a meeting between a group of Sandia staff and managers and a group of faculty and administrators from UTMB, a joint recognition dawned,

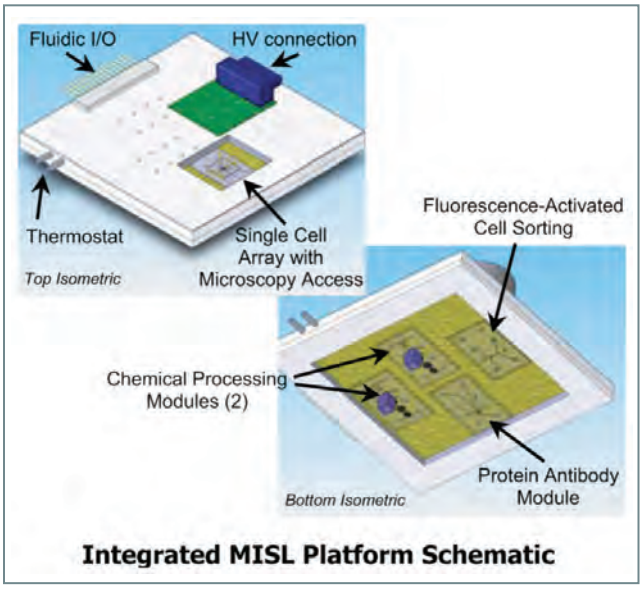
according to then MISL project manager Glenn Kubiak. "We recognized that Sandia and UTMB shared the mission of biodefense and brought similar and synergistic tools to the table." In UTMB's case, the tools were an expertise in biological signal transduction — the molecular mechanisms and diversely interconnected pathways of cell signaling — and biocontainment laboratories with the ability and expertise for handling and conducting experiments on dangerous biopathogens. Sandia offered three capabilities related to its depth and expertise in micro and nanoengineering: microfluidics technologies, high-content spectral imaging, such as the hyperspectral microscope, and computational power to complement the significant bioinformatics capability of UTMB.

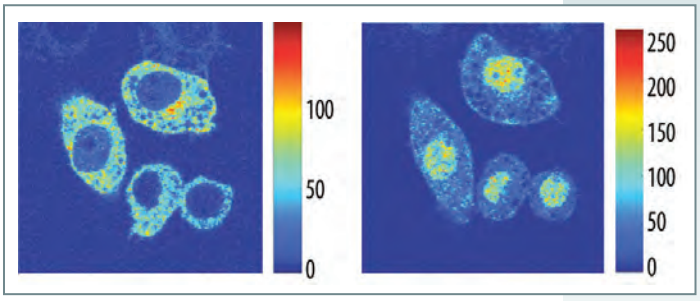
The partnership recently entered its third phase. Phase one encompassed several tactical seed investments. UTMB faculty such as Alan Brasier were already involved as research partners in MISL, and with the consent of then Vice-President for Science, Technology, and Engineering Foundations (ST&E), Rick Stulen, a portion of the MISL funding was utilized to fund joint UTMB-Sandia postdocs. In addition, several seed projects were initiated with Sandia LDRD funding matched by UTMB funds in areas such as microfluidics assays, reliable identification of biomarkers for early-stage identification of infection by biowarfare agents, and analysis of stochasticity in cell signaling; these are projects all germane to a better ability to identify infections and a better understanding of the interaction of infectious agents with the immune system and the inflammatory mechanisms thus initiated.

In true collaborative fashion, phase two of this partnership has engendered the submission and funding of a flurry of grant proposals to the National Institutes of Health (NIH) and the National Aeronautics and Space Administration (NASA). This has returned almost $30M per year in funding, a portion subcontracted to Sandia for device engineering, with projects such as one in clinical proteomics led by UTMB's Brasier and including Sandians Anson Hatch and Gabriela Chirica, and another in clinical science, whose board is chaired by Sandia director, Glenn Kubiak. UTMB is the Western Regional Center of Excellence for NIH's National Institute of Allergy and Infectious Diseases (NIAIDs), and its dedication to the Sandia partnership is illustrated by its reserving 10% of its NIH award for the Sandia collaboration, despite the fact that it had suffered a significant overall decrement in funding levels.

In the case of NASA, Sandia has an opportunity to contribute to a breakthrough in astronaut real-time health monitoring. This obviously requires a small, lightweight, low-power-consumption device that can function in space to rapidly analyze convenient body fluids such as saliva for biomarkers to alert NASA ground stations to any changes in an astronaut's health situation. Ironically, this same

In true collaborative fashion, phase two of this partnership has engendered the submission and funding of a flurry of grant proposals...





Images from the Sandia MISL project, which served as one important seed for aspects of the Sandia-UTMB partnership. Left: drawings of the microfluidics platform for isolating single cells. Right: hyperspectral images of immune system macrophages.

…training of a new generation of modern bioscientist has, indeed, become a stated objective of the Sandia-UTMB partnership.

sort of device — as high-tech as space flight itself— could also function in resource-poor settings on earth to bring a level of diagnostic sophistication to physicians in underdeveloped regions that would otherwise lack it.

"This ship has sailed . . . has its own life," comments Anup Singh, former PI of MISL, and a key figure in the research integration with UTMB. "You can't dial this partnership back," he adds, exhibiting a confidence that the ongoing collaboration is so valuable to both institutions that to allow it to falter would be intolerable in both cases.

Phase three of the partnership amply underscores Singh's exclamation. Both Singh and Kubiak describe this as developing into more of a consortium, a "Houston cluster" or "Gulf-coast consortium" bringing biomedical science and technology to the Texas coastline notorious for its petrochemical industry, the biomedical initiatives almost springing up like a phoenix from the oily residue preceding them. Including UTMB, the University of Houston Health Sciences Center, Baylor University, and the MD Anderson Cancer Institute, it is a health sciences group that could greatly benefit from Sandia's expertise. While it is clear that cancer research is not part of Sandia's mission, it is just as evident that many of the cell-signaling pathways and immunological mechanisms relevant to infectious disease pathogenesis are also relevant to cancer, and so the crossover is almost unavoidable. Wajid Hermina, Senior Manager of Sandia's Sensors and Communication Microsystems, is championing the Sandia-MD Anderson relationship as it gradually develops.

There are several keys to phase three, but the overarching umbrella is the concept of a Joint Institute for Biodefense Technical Acceleration and Commercialization (JIBTAC). As the name suggests, the idea is to combine Sandia micro-engineering with UTMB biomedical expertise to generate data proving the utility of newly created solutions to pathogen diagnostics, then involve small companies as partners in the production of the technologies. It is clearly neither within UTMB's nor Sandia's mission spaces to either manufacture on any scale beyond that of a prototype, or to commercialize such new technologies. To move emerging biodefense technologies across the valley of death requires such partnerships and is consonant with President Obama's formation of the Biomedical Advanced Research and Development Authority (BARDA) within the Federal Department of Health and Human Services, the goal to develop and disseminate biodefense countermeasures.

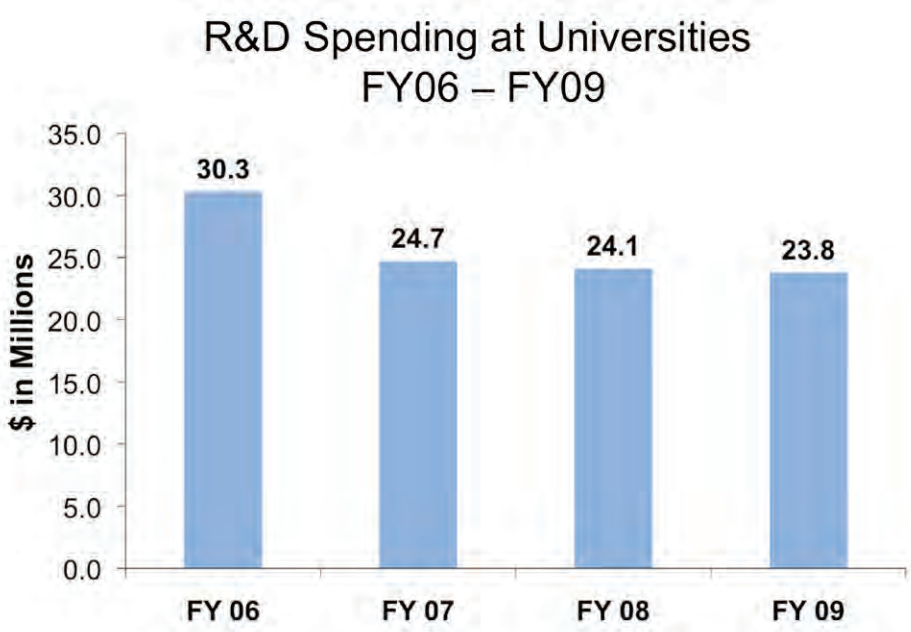
The conceptualization of JIBTAC coincides with a land grant from a benefactor, a real-estate developer whose wife desired to contribute to UTMB. The donated land, along the I-45 corridor near Texas City, across the bay from Galveston, forms the base for a research/commercial center serving as an incubator for the state's initiatives to transform this Gulf Coast corridor into a biodefense community. "Seeing a JIBTAC sign from I-45 is a vision that galvanizes myself and Anup," Kubiak reveals.

But there is a perhaps even more important aspect of such a vision, which involves the training and generation of a new generation of bioscientist. Reflecting on the initial almost oil-in-water mixing of micro-engineers and biologists that characterized the onset of MISL — which eventually settled into a stable mixture where cooperation engendered genuine solutions — Kubiak believes that the experience points up the need for research scientists who possess both capabilities, that is, an expertise in both fundamental cell and molecular biomedical science and bioengineering. This training of a new generation of modern bioscientist has, indeed, become a stated objective of the Sandia-UTMB partnership. Ultimately, Kubiak hopes for the development of a more Campus Executive–style partnership between Sandia and UTMB, and he imagines the possibility of a staff pipeline that would take the form of joint faculty/staff appointments to both institutions. This would appear to be a future vision worth nurturing.

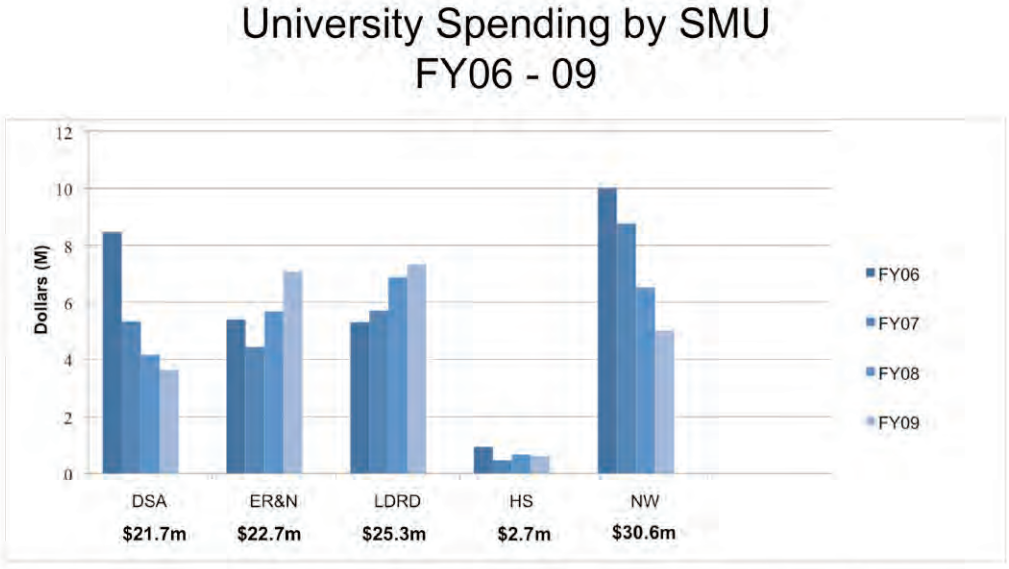
Research Investment and Talent Capture

Investments in university research continue to pay off for Sandia and for US taxpayers. This University Partnerships Annual Report showcases the results of these investments. Our accomplishments can be measured by new and existing collaborations with university partners, the number of new employees hired, and by the amount of research dollars sent to universities by organizations at Sandia. Many new collaborations include joint research projects with the National Science Foundation (NSF), the National Institutes of Health, Department of Defense (DoD), and User Agreements with university partners at the Center for Integrated Nanotechnologies (CINT). These collaborations are forged through the individual efforts of participants in the Campus Executive Program, Graduate Research Program, PECASE and SURP.

Research Investment



Trend data shows the total amount of research dollars spent by Sandia at US universities

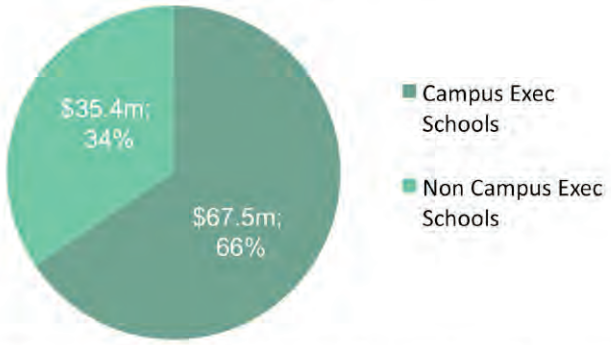


DSA: Defense Systems & Analysis; ER&N: Energy, Resources & Nonproliferation; LDRD: Laboratory-Directed Research & Development; HS: Homeland Security; and NW: Nuclear Weapons Strategic Management Units

Trend data shows the amount of research dollars spent at US universities by Sandia Strategic Management Units (SMU)

66% of research dollars invested went to campus executive schools

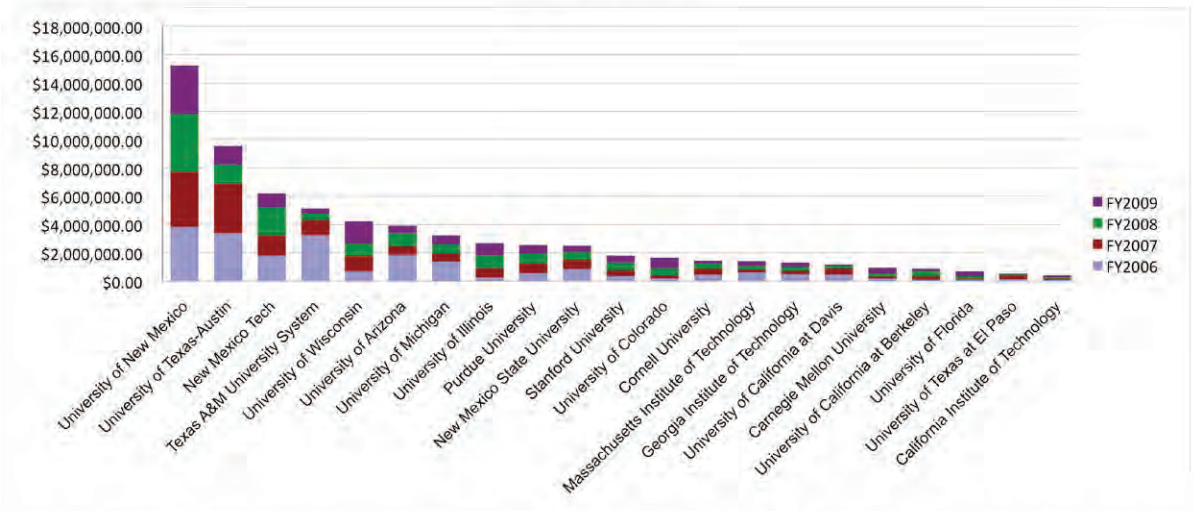
Total Research Dollars to CE Schools FY06-09



Of ~$103m total research dollars invested, 66% went to campus executive schools

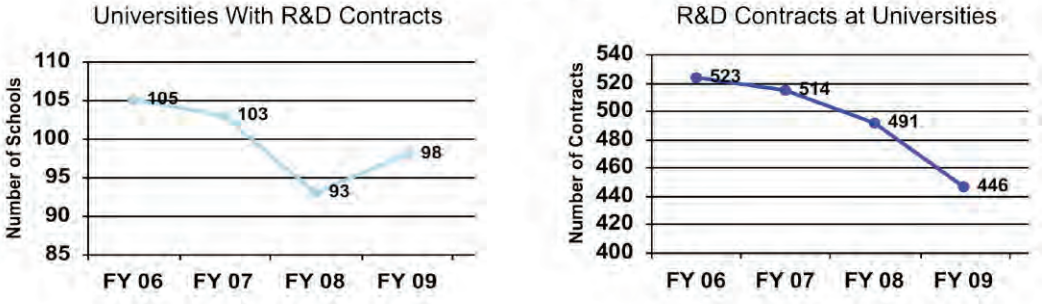
Labs-wide research investment at each campus executive school

Research Dollars to CE Schools FY06-09



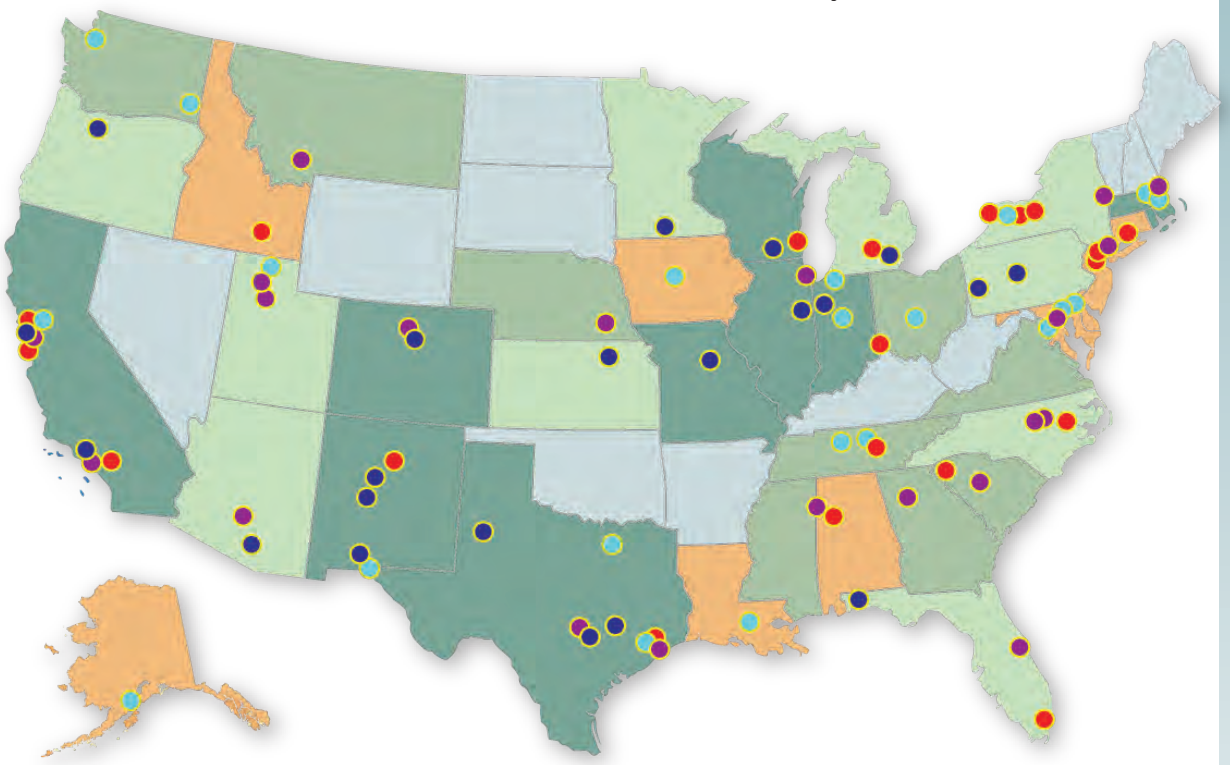
Five campus executive universities received >$4m of research funding: UNM, UT-Austin, NM Tech, TAMU, and University of Wisconsin

Investment in University R&D FY06-09



Data depicts the number of US universities with which Sandia has placed R&D contracts; and the number of contracts placed with US universities

Total Investment FY2009 in University R&D



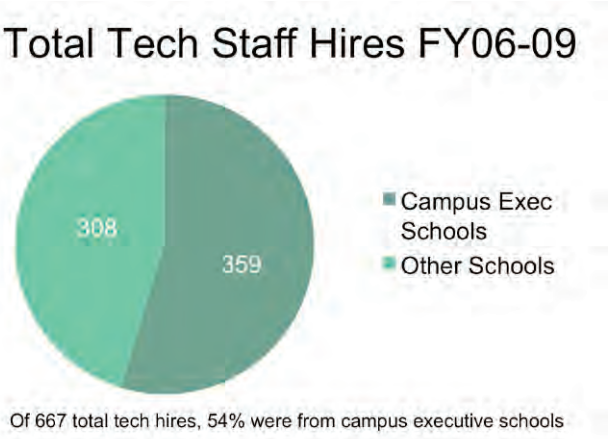
Total Investment by State

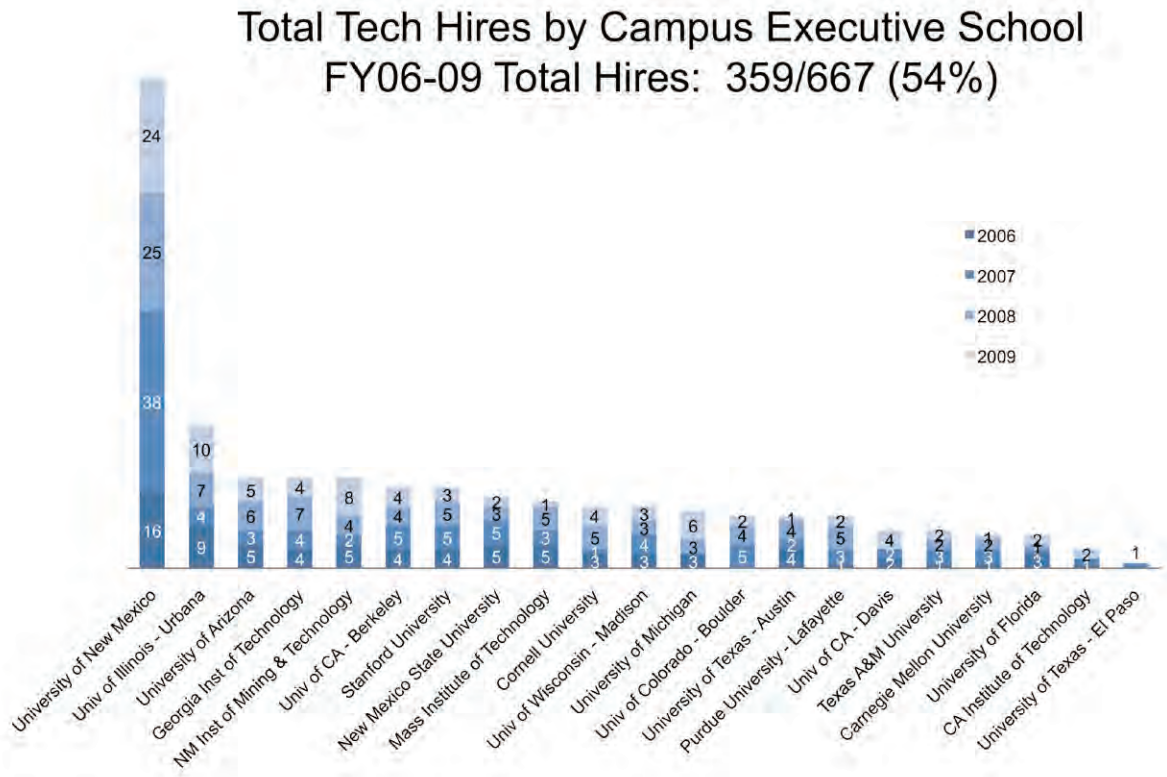
Total Investment by School

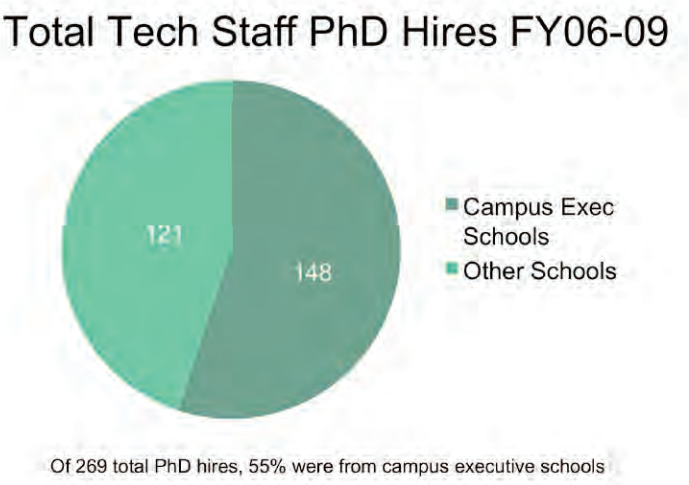
Talent Capture

54% of all tech hires come from campus executive schools

Total Tech Staff Hires data shows that 54% of all tech hires come from campus executive schools. PhD, MS, and BS hires by totals over the four-year period; and by campus executive versus non-campus executive schools are also reflected. Only those universities with 3 or more hires were included.

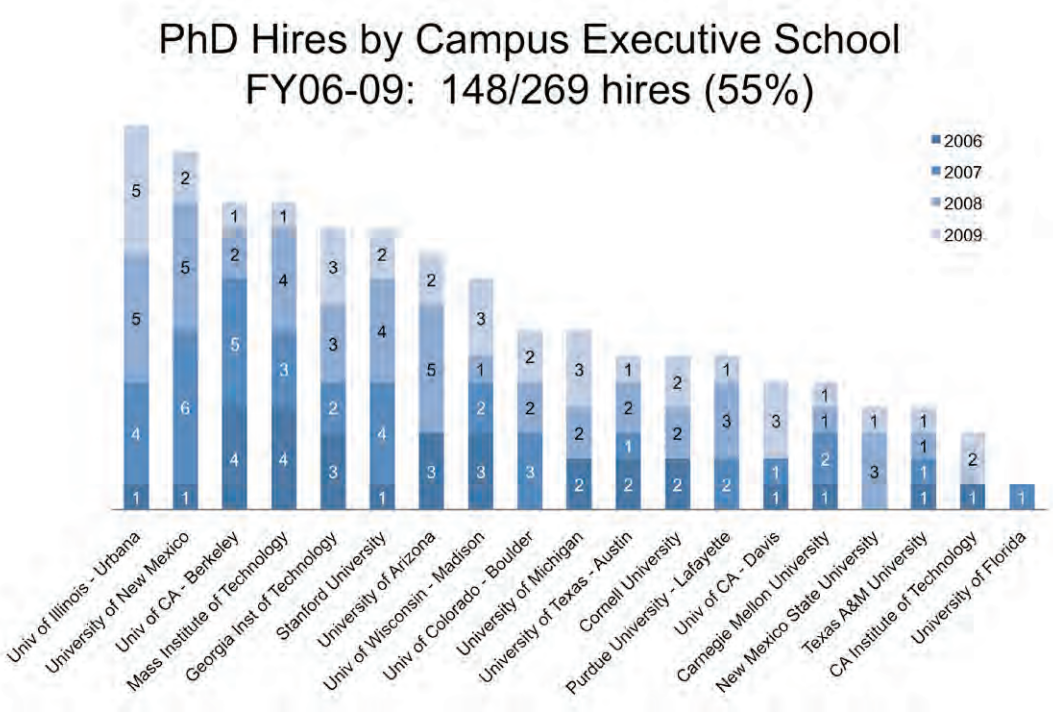




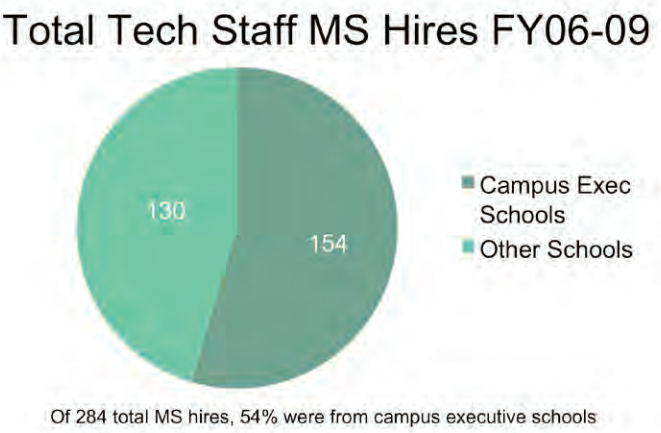


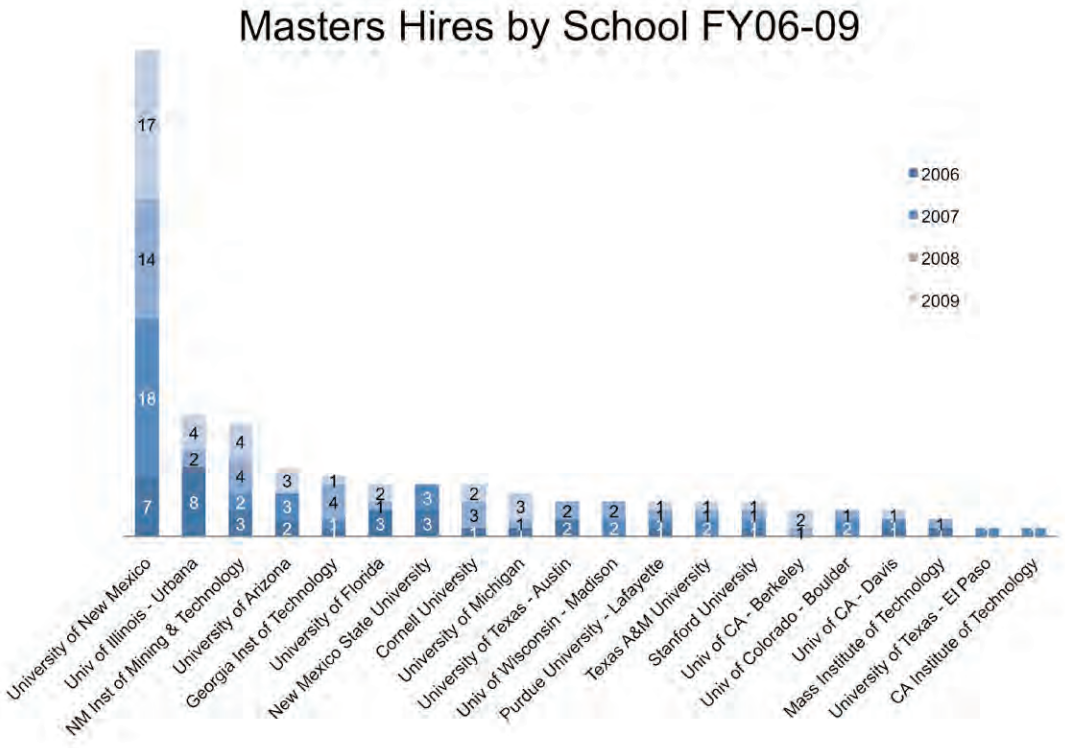
Of 269 total PhD hires, 55% were from campus executive schools

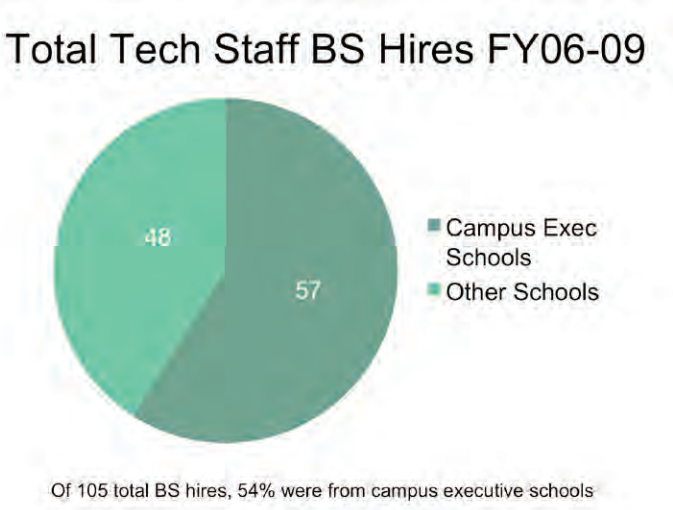
55% of PhD tech hires come from campus executive schools



54% of MS tech hires come from campus executive schools

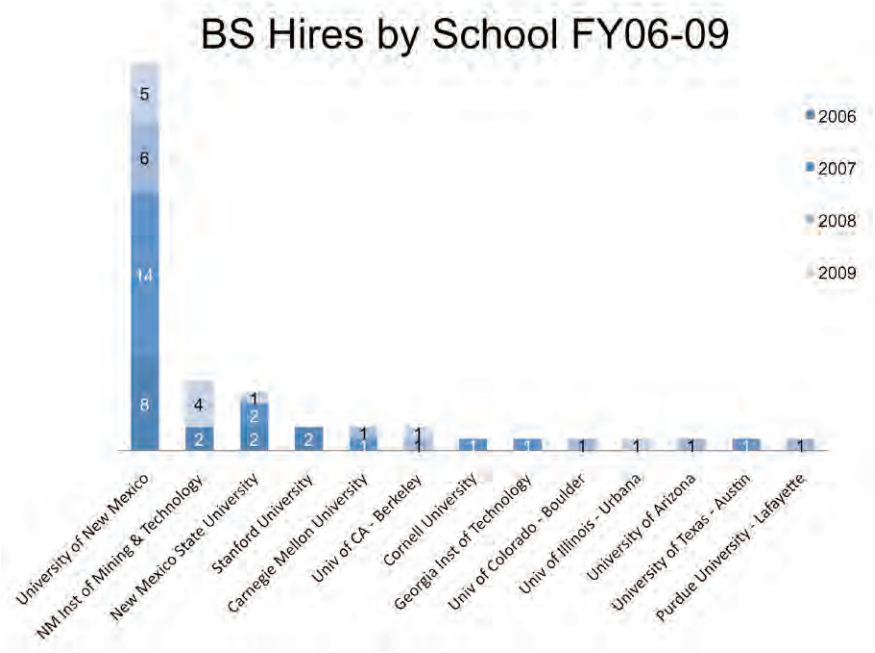




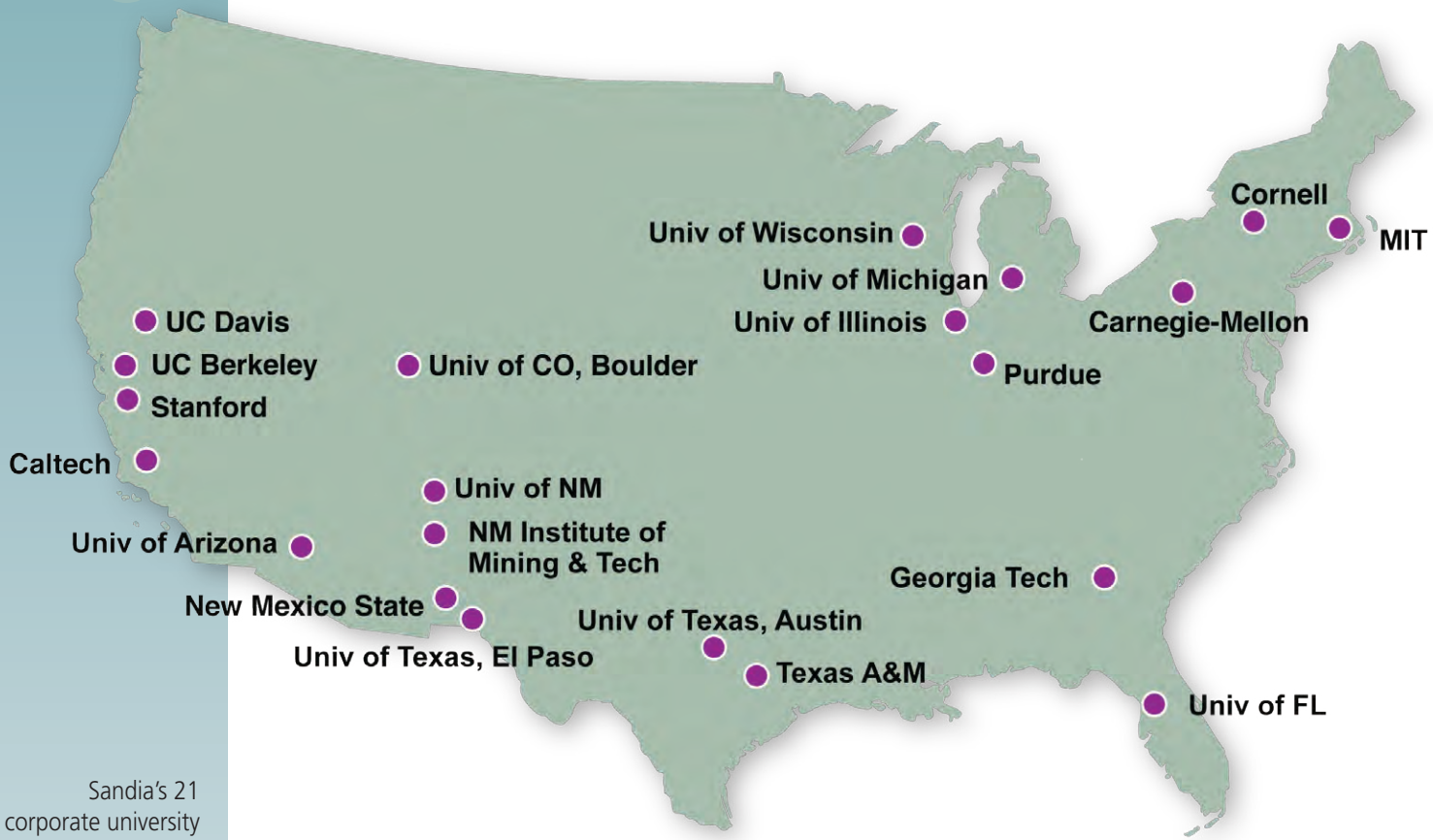


Of 105 total BS hires, 54% were from campus executive schools

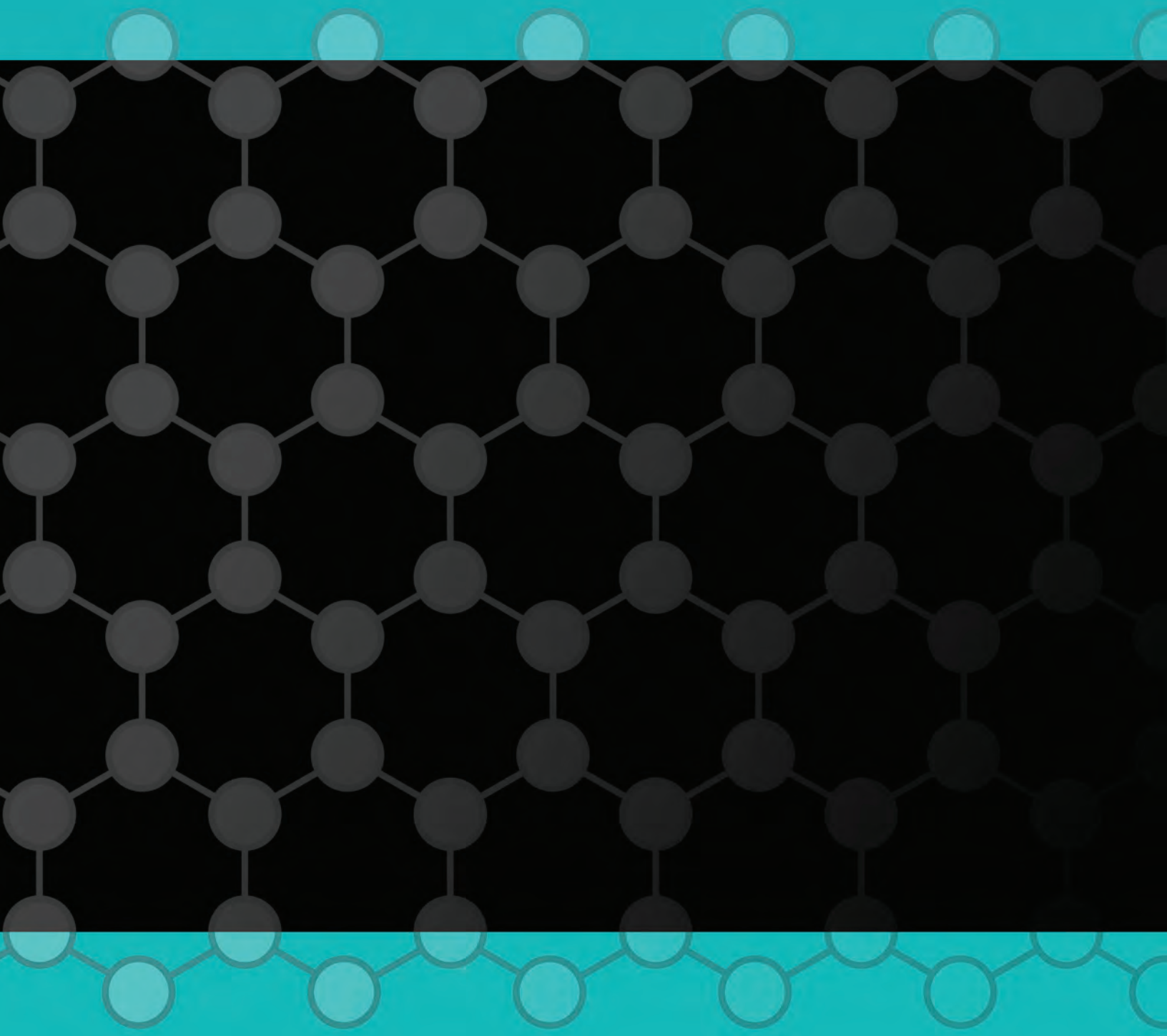
54% of BS tech hires come from campus executive schools



Campus Executive Schools



Sandia's 21 corporate university partners



Sandia National Laboratories